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THE HUMAN BODY

A STAR BOOK

THE HUMAN BODY

By

LOGAN CLENDENING, M.D., 1884-1945.

Illustrations by

W. C. SHEPARD AND DALE BERONIUS

AND FROM PHOTOGRAPHS

1930.

> *Fold your flapping wings,*
> *Soaring legislature!*
> *Stoop to little things—*
> *Stoop to human nature!*
>
> —IOLANTHE

STAR
BOOKS

GARDEN CITY PUBLISHING COMPANY, INC.
GARDEN CITY, NEW YORK

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TO PETER THOMAS BOHAN, M.D.

Dear Pete:

You and I have watched together at many bed-sides, we have shown one another many pathologic specimens, ensconced temporarily, to the horror of our respective wives, in our respective bath-tubs, and we have sat over many a mug of grog far into many nights discussing battle, murder, and sudden death. In the hope that we may both long be preserved to indulge these relatively innocent pastimes, I dedicate to you this unworthy brochure.

I was asked to write it in order to make intelligible some of the intricacies of the human body for the adult and otherwise sophisticated reader. It does not, therefore, have quite the same point of view either as a school physiology, as one of those compendia of household diagnosis and treatment, or as any of those little volumes with some such title as *What a Girl of Eighty Ought to Know* or *What a Man of Fourteen Ought to Know.* It has no rules for the sudden acquisition of health. It is not designed to prolong anyone's life. There is too much of that sort of thing going on already. When you glance over your well-filled library you will, of course, see that I have had, on account of the limitations of my space, to omit many topics. You will probably think I have given others undue prominence. In short, I am afraid you will find that I have left out all those things which I ought to have put in, that I have put in all those things I ought to have left out, and that there is no health in it.

Yours affectionately,

THE AUTHOR

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PART I

THE HUMAN BODY AS A UNIT

CHAPTER I

A DEFINITION

The human body is an animal organism, differing in only a few respects from other animal organisms, and fitted, by the processes of selection and evolution, for the performance of two main functions:

(1) The conversion of food and air into energy and into tissue.

(2) The reproduction of other individuals of its species.

As a physiologist I have no data upon which to base a belief that it has been designed for any other purpose or destiny. Why it has been developed to its present state upon this tiny globule of dust in this obscure corner of the universe, why it continues monotonously repeating itself generation after generation, for no other apparent object than to litter up the verdure of the earth with images of its obscene gods, with its hideous habitations, and with the poignant mementoes of its dead — what these things mean are matters to which I have not been made privy. Certainly there is no clue in the structure or functions of the body itself. As a philosopher I may engage in some speculation on the subject in the company of Plato, Schopenhauer, and the Archbishop of Canterbury, but it is to be recognized that when I do so, my speculations are themselves based upon speculations and not upon anything resembling observed facts.

Sentimentalists will complain that my definition omits two of their favourite themes — one, the operation of man's intellect, and the other, the tribulations of his spirit. In short, it leaves out mind and soul. But I think that, on the contrary, it includes them. For in the twofold function that he is called upon to perform he first must needs acquire food to supply his energy, and shelter to preserve it, and secondly, in order to reproduce, a mate must be secured. And I submit that to do the first is the particular function of the mind, and to do the second is the particular function of the soul. I recognize that in a state of civilization such as exists to-day both of these things have become absurdly easy, and the mind and soul, being restless pieces of machinery, are perverted into other channels. When a man is no longer under the grinding necessity of acquiring food for his next meal, he will turn to other things — to the operations of the stock exchange, to politics, racehorses, or the gathering of first editions. When a woman no longer needs to exert any mystical fascination of limb or lip to capture a sugar-broker, she turns to lyric poetry or dyspepsia. But in none of the variegated depravities of the mind or soul — the plan of the battle of Austerlitz, the Fifth Symphony, the ritual of the Holy Communion, the belfry tower at Bruges, the organization of the Standard Oil Company, the "Ode on a Grecian Urn," or Rob Haselton's collection of postage stamps — can I discern anything but a weak disguise either of the means to acquire food and shelter that they may be converted into energy and tissue, or of the means to acquire a mate in order that another individual may be reproduced.

CHAPTER II

KNOWLEDGE OF THE HUMAN BODY AS A FACTOR IN CIVILIZATION

In a much admired and frequently repeated passage Huxley compares a knowledge of the human body to a game of chess. The luxury of quotation is too considerable to resist:

"Suppose it were perfectly certain that the life and fortune of every one of us would, one day or other, depend upon his winning or losing a game at chess. Don't you think that we should all consider it a primary duty to learn at least the names and the moves of the pieces: to have a notion of a gambit, and a keen eye for all the means of giving and getting out of check? Do you not think that we should look, with a disapprobation amounting to scorn, upon the father who allowed his son, or the state which allowed its members, to grow up without knowing a pawn from a knight?

"Yet it is a very plain and elementary truth that the life, the fortune, and the happiness of every one of us, and, more or less, of those who are connected with us, do depend upon our knowing something of the rules of a game infinitely more difficult and complicated than chess. It is a game which has been played for untold ages, every man and woman of us being one of the two players in a game of his or her own. The chess-board is the world, the pieces are the phenomena of the universe, the rules of the game are what we call the laws of nature. The player on the other side is hidden from us. We know that his play is always fair, just, and patient. But also we know to our cost that he never overlooks a mistake, or makes the smallest allowance for ignorance. To the man who plays well the highest stakes are paid with that sort of overflowing generosity with which the strong show delight in strength. And one who plays ill is checkmated — without haste but without remorse."

Huxley was here inveighing against the classical education of his day, which entirely ignored instruction in natural science, including human physiology, somewhat on the ground of the remark made by the mistress of a ladies' seminary that it was "not quite respectable for persons to know about their insides."

H. G. Wells, in a foot-note to the *Outline of History*, delineates Gladstone as an example of this age. One of his annotators has protested against Wells's estimate of Gladstone's learning. "Men with such training," he says, after describing the school of *Literæ Humaniores* at Oxford, "were genuinely and nobly trained in statesmanship." To which Wells dryly replies: "With no knowledge of ethnology, no vision of history as a whole, misconceiving the record of geology, ignorant of the elementary ideas of biological science . . .!"

Times have, it is true, changed since Huxley's day and it is largely due to his influence. In our schools now biology is taught and with it the structure and the functions of the human body. Not very well yet, not with any whole-hearted emphasis! The course in physiology is a "soft" course, not to be compared in importance with the study of the record in the original Latin of Julius Cæsar's conquest of a few savage tribes in Gaul.

A great part of the books used in the physiology course are filled with a pious pedantry designed to instil a horror of alcohol, adultery, house-flies, and school desks and devoted over whole tracts to accounts of the derogatory effect of tobacco on scholarship.

Man's interest in the mechanisms of his own body has, however, never been as suppressed or as suppressible as Huxley's words would seem to indicate. His world has always been grounded solidly upon his body as its centre. From it and its necessities he has circled out and learned what he knows about the universe. It is a true saying that "medicine is the mother of the sciences" — simply because the medical profession's primary interest was the human body, and the profession was for most of the period of the world's history the only organized body of men using the scientific method — which is the accumulation of data without religious or political prejudice — in any field of the study of natural phenomena. There is a passage in *Main Street* in which Carol has been bewailing the lack of interest in literature and science in her little town, to which her husband, Will Kennicott, the country doctor, replies gravely and patiently: "Yes, I'm about all the science there is around here." That has been the position of medicine through many and long dark periods of the world's history and in many lonely and unlighted places. It was all the science that there was. But because it kept the lamp burning and because man's primary interest is his own body the other sciences were born.

Mathematics, for instance, derives its patterns from the human body. There is no reason why the numeral ten or the decimal system should be such a favourite except that we have ten fingers. When a primitive hunter saw a number of deer in the forest and conceived a perfectly natural desire to go home and tell how many there were, he counted them up on his fingers.

Dr. Vilhjalmur Stefansson informs me that a primitive race today, the Eskimo, base their counting on the human body. Their word for five is the same as their word for the arm (i. e., five fingers); for ten the same as "the uppers"; for nineteen "one less than the whole man"; for twenty "the man finished." Sixty-nine is "three men and one less than the uppers." Eighty is "four men." Seventy-nine is "one less than four men." Four hundred is "twenty men." "Of course," writes Dr. Stefansson, "in their remarkably precise language these expressions are not so clumsy as in my translation."

The stars and comets and the sun; the moon varying in its phases in the same time-cycle with the issue of blood from his females, became associated in the barbarian's thoughts with his destiny and his discomforts; he began to study them, and astronomy was born.

Plants, because they were found to be necessary as foods for his body, because he liked their taste, drew his interest. Somewhere, some time, one of the greatest discoveries in the history of the race was made — that the plants he needed could be grown from their seeds — and botany was born. The influence of the herbs which healed or which gave relief from pain (the use of opium for medical purposes is one of the oldest of human practices) upon the science of botany is obvious enough. The list of things man has learned about nature because of the necessities of his own body might be indefinitely extended.

But any exact knowledge of nature, including that concerning the human body, was not permitted in primitive times to be developed unrestricted by limitations. It fell, in fact, into the hands of the priests. Among primitive people, and even in such highly organized national civilizations as those of Assyria, Babylonia, Egypt, and Greece, the priesthood interpreted the portents of the heavenly bodies, blessed the domestic animals and crops, gathered and administered the herbs, and announced in what way the celestial universe affected the individual bodies of men from king to peasant. When the priesthood began to explain to the parishioners committed to their care the causes of the maladies of their bodies — their deformities, their fevers, their convulsive fits, their swellings, their throbbings — they quite naturally, quite subconsciously, I believe, and quite sincerely played their own game. It was too good a chance. If a man became paralysed, it was because he had lost his faith in the god, and the god must be propi-

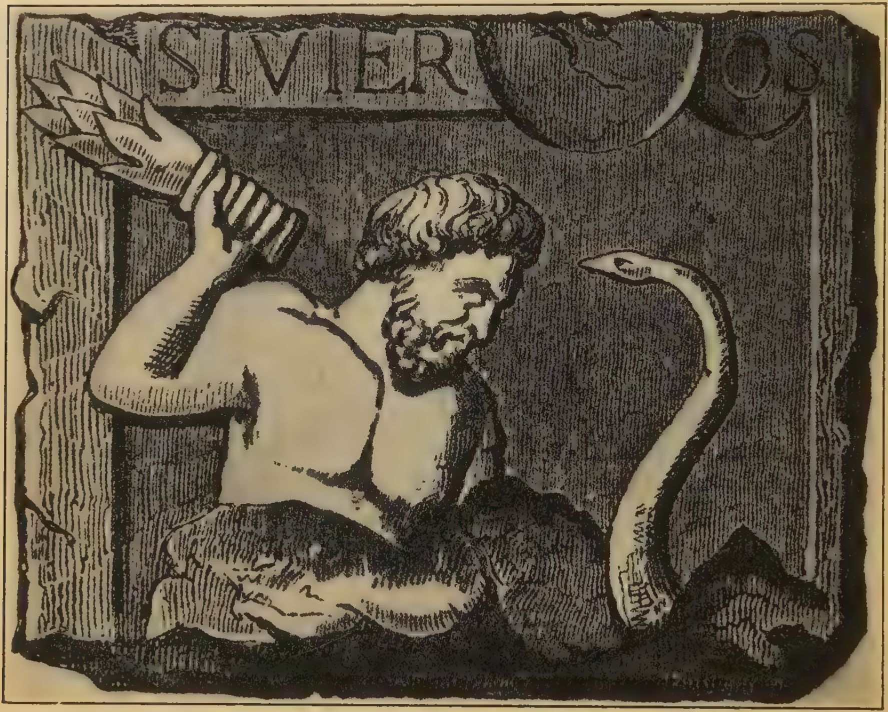

FIGURE 1

Æsculapius dispatching a demon. From a bas-relief. This represents the primitive man's conception of disease — that it was due to the entrance into the body of a demon or a devil, or that it was due to the fact that the sick person had sinned, or had lost faith in a god. Treatment based on this primitive conception would naturally be either to exorcize the demon or to compel the patient to renounce his sin or to proclaim his faith.

tiated. If a man swelled with a tumour, it was because he had sinned, and again the god must be propitiated. If a child had fits, it was because devils had entered into him; he must be brought into the temple; gift offerings, preferably in the medium of exchange current, must be made to the god. The custom still exists. The Christian Science Church is founded on the doctrine. Unity, which is to Christian Science what chiropractic is to osteopathy, is founded on it. The solemn conclave of the House of Bishops of the Episcopal Church of the United States at their last General Convention was asked to pass upon the claims of a healer named Hickson, developed inside the holy body of their own Church in England, and whose sole doctrine was that disease was due to lack of faith and unkind thoughts about others.

Now, of course, to free mankind from these asinine ideas was a long and arduous task. So far as the human body is concerned, that task has been accomplished largely by the regular medical profession. The profession's service to human freedom, the contributions which a lewd and obscene curiosity into the workings of the human body has made to human freedom, have never received adequate acknowledgment from any historians, even the historians of liberty. Perhaps for the reason of that delinquency I may be allowed at the outset to make brief mention of two names — Hippocrates, and Vesalius.

The name of Hippocrates is familiar enough as a name. The average educated man would probably react to it by the words "the father of medicine." The average physician would be able to go little if any further. His name is not even listed in the indices of half a dozen compendia of history which are on my shelves, including that of Wells, who certainly is inclined to give science its due credit in shaping civilization.

Yet Hippocrates was one of the great human liberators. In his youth he saw very regularly the state of medical thought in his own time. He was the son of one of the priests of the Asclepiadæ.

In the chlorotic prose of Walter Pater, at the third chapter of *Marius the Epicurean*, is a description of the rites in a temple of the Asclepiadæ. Here, in the tones of the Oxford accent, you will find distilled the philosophy of Bernarr Macfadden in paragraph two, the philosophy of Sigmund Freud in paragraph three, and of the Palmer School of Chiropractic in paragraph ten. The temples of Æsculapius harboured patients for a few days and subjected them to a prescribed ritual. They were first purified by bathing in a mineral spring; massage and inunction might also be given. The sacrifice of a cock or a ram was made before the image of the god. The patients were persuaded to sleep, the rite of "incubation" or temple sleep, and during their rest priests came and talked to them. If the patient dreamed, he was encouraged to recount his dream, which the priest then interpreted; they also prescribed cathartics, blood-letting, emesis, and herbal medication.

These practices have a sort of superficial appearance of rationality. But the deep basis of theory upon which it all rested was that disease was due to "the displeasure of the god." There was no natural law about the functions, either in health or sickness, of the human body. Evil spirits entered in, like the devils which were driven into the Gadarene swine, or the patient had sinned, or had lost faith. This in the fifth century B. C. — the age of Plato and of Euripides.

With such superstitions Hippocrates suddenly and sharply broke. He was the first and greatest physician not because he was the only one of his day, not because he founded an ethical code with the Hippocratic oath, but because he first threw aside all the demonology of the priests and looked upon disease as part of the order of nature, having a natural cause and a certain course; which course could be studied and recorded and which could, within certain limitations, be predicted and even altered. Read his famous description of the Hippocratic facies. Here it is:

"A sharp nose, hollow eyes, collapsed temples; the ears cold, contracted, and their lobes turned out; the skin about the forehead being rough, distended, and parched; the colour of the face being green, black, livid, or lead-coloured. If the countenance be such at the commencement of the disease, and if this cannot be accounted for from the other symptoms, inquiry must be made whether the patient has long wanted sleep; whether his bowels have been very loose; and whether he has suffered from want of food; and if any of these causes be confessed to, the danger is to be reckoned so far less; and it becomes obvious, in the course of a day and a night, whether or not the appearance of the countenance proceed from these causes. But if none of these be said to exist, and if the symptoms do not subside in the aforesaid time, it is to be known for certain that death is at hand."

What does that passage mean? It is a description of impending death, as its appearance may be discerned in the face. Hippocrates does not suppose that any of these signs are due to the entrance into the body of an evil spirit, or to the position of the planet Saturn, or to some sin the patient had committed, or to his lack of faith in Poseidon. It is perfectly evident from what he says that he regards this as the natural outcome of the interplay of factors which are liable to arise in the course of certain diseases. Furthermore he is not deceived as to what they mean. They mean death, and when that combination of signs and symptoms arises, nothing that he has ever been able to do has averted that result.

The literary style of Hippocrates is very austere, and he nowhere leaves his path to controvert the priestly views of disease prevalent in his own day, but his influence was wide and deep. Certainly from his day dates the decline of the Asclepiadæ, though they were still in existence five hundred years later and visits were made to them, much in the spirit in which a modern man goes to church, because it is a family tradition. The rise of observational medicine dates from Hippocrates. There was none before. How could there be? Disease was from the gods. And the gods were capricious. Why study the rules of something that had no regularity?

Two men who dominated human thought for fifteen centuries fell beneath the intellectual stimulus of Hippocrates. The final result of their leadership was harmful, but that is always true when a set of ideas falls into the hands of pedagogues. Aristotle and Galen initiated the reign of the pedants.

Aristotle was deeply influenced by Hippocrates. And Aristotle was a great liberator, partly because he was interested in the human body. Not, strictly speaking, a physician, he first examined animal bodies in the scientific spirit, deducing from what he found in them speculation as to what went on in man's body (in *De Partibus Animalium*). No one, I think, has put Aristotelianism into a sentence, yet it can be done. He believed that man could master his world. Man unendowed, save with his five senses, unaided by priestly advice or by divine inspiration, could find out the composition of the earth, what it contained that was useful, how human and other animal bodies worked, what were the well-springs of joy (in the *Poetics*), how he could enter into the vastnesses of the sea (in a submarine) or launch himself into the airy firmament (in an airplane), what his enemy Disease was and how it could be combated. Such was the secret of that incredible activity of Aristotle's — studying now fishes and now politics, now ethics and now minerals. And man has justified Aristotle's conviction: man has conquered his world.

Galen, who with Aristotle shared the throne of scholastic authority in the Middle Ages, belonged to a later century and a different era. It was the brazen commercial world of Græco-Rome. Galen was born in Pergamos, he lived in Rome and he wrote in Greek. He was perfectly typical of his age. Indeed his age being much like our own, he was not unlike a fashionable physician of to-day. He was shrewd, meretricious, garrulous, boastful, incredibly disputatious, and more than occasionally correct. His writings are so voluminous as to make the Holy Bible look like a pamphlet. He treated emperors, courtesans, wine merchants, generals, senators, vestal virgins, oriental rug dealers, philosophers, and gladiators. He tells of all his patients, and of the little tricks he used to arrive at his diagnoses. His case histories undeniably have a flavour.

He specialized in omniscience. He was a second-rate genius, exalted by the pedants of Oxford and Padua to the status of a god. His knowledge of anatomy was learned entirely from dissections on animals. And for twelve hundred years the brilliancy of his rhetoric prevented men from learning at first hand anything about the human body.

Finally the legions of light were drawn up and one other battle was fought in the name of the human body for human freedom. Its hero has been even more ignored than Hippocrates — Vesalius, who first recorded completely and accurately the structure of the body. But not until 1543, when his *De Humani Corporis Fabrica* was printed. It is one of the great epoch-making books of the world, ranking with *De Revolutionibus Orbium Cœlestium*, *The Wealth of Nations*, and *The Origin of Species*.

In that long sleep of the intellect known as the Middle Ages there was no space for the study of Nature. The Catholic apologists — for instance, Walsh in *The Popes and Science* — have tried to make out a case for the encouragement the Church gave to research. That is, of course, nonsense. It must be said, though, that the Church was not the sole or even an active factor in the lack of advancement. That the Dark Ages were dark, that it was a period of brutal universal ignorance, was not anybody's fault. "Truth is the daughter of time." When the Renaissance came, it came to science as well as to art, and when the Church started to crusade against science, it lost not only every campaign but every skirmish.

To human dissection the Church would naturally hold very strong and superstitious objections. The resurrection of the body was a pretty real thing to the mediæval mind, and the body would have to have spleen, liver, and tibia in eternal bliss. Mondino, who appears to be the first to have made systematic human (in contrast to animal) dissections, observed the papal bull of Boniface VIII against the boiling of human bones, and thus cut himself off from knowledge which the study of a cleaned bone would give. Singer, in his history of anatomy[1] argues that the Church did not really interfere with human dissection and that this bull was issued for other purposes, but I believe he minimizes the objection which religious zealots, even yet, have to the removal of parts of the body before burial.

But a much more determined opposition to human dissection came, not from the Church, but from the universities, from men ironically called humanists. The influential scholars in the period of the revival of learning based their anatomy largely on the dictates of Galen, partly on Aristotle. The anatomy of Galen and Aristotle was based upon the dissection of animals. Writing, as Galen did, with vivid dialectic skill and spice, he impressed his opinions upon his students with great force. And the scholastic squabbles of the late fifteenth and early sixteenth centuries were due, incredible as it may seem, to debating whether the human body corresponded to Galen's description of it. Sylvius, the most bitter enemy Vesalius had, even went to the length of saying that man had "changed, since Galen's time, but not for the better."

Against this massed tradition of ignorance and bigotry Vesalius launched himself with blunt vigour. The body was his Bible, as he often said, and he cared not how he obtained copies. In Paris

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[1] Charles Singer, *The Evolution of Anatomy*. Alfred A. Knopf, 1925.

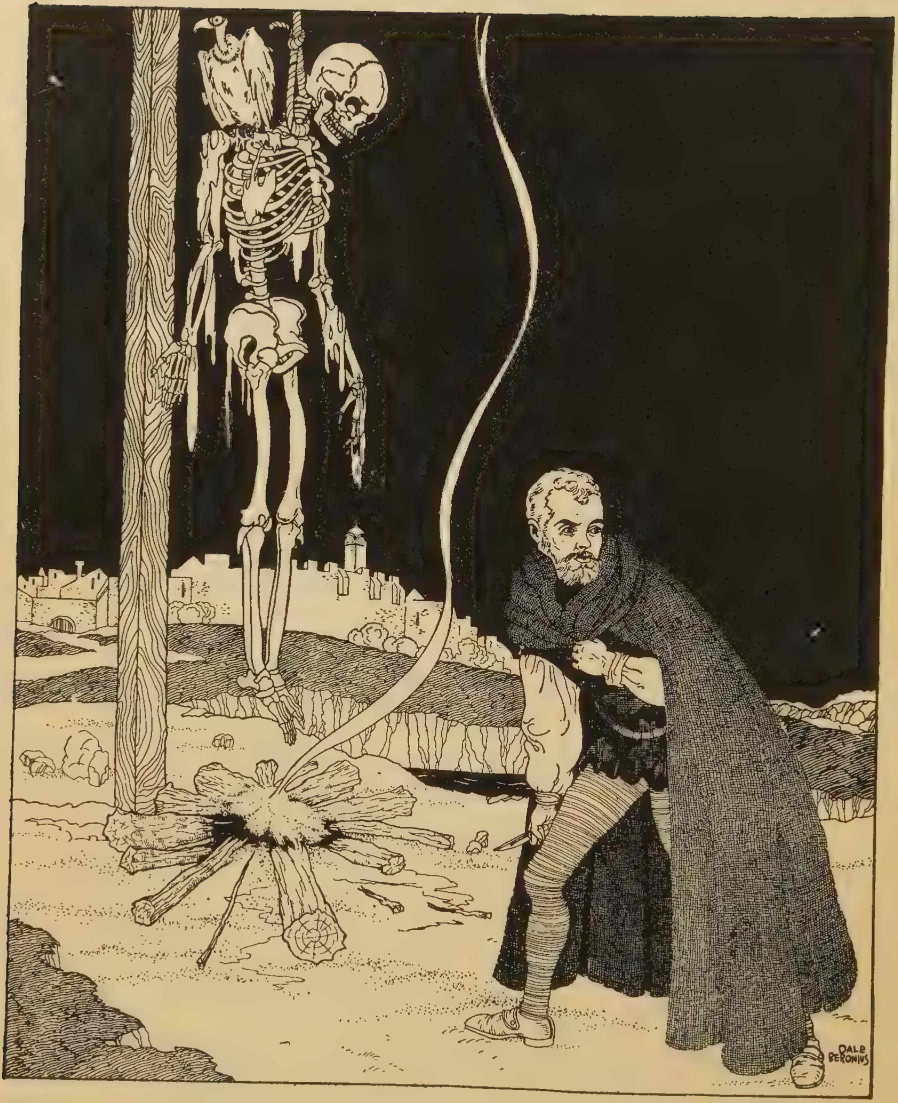

DALE BERONIUS

FIGURE 2

Vesalius obtaining his first skeleton outside the walls of Louvain.

he found that he could steal bodies from Montfaucon, that spot which chatters in the pages of François Villon, where the bodies of criminals were hung upon the gibbets. In Louvain he sneaked by night to remove bodies from the gallows. On one occasion he discovered the body of "a noted robber, who, since he deserved more than ordinary hanging, had been chained to the top of a high stake and roasted alive . . . by a slow fire made of straw, that was kept burning at some distance below his feet. In this way there had been cooked a dish for the fowls of heaven, which was regarded by them as a special dainty. The bones, therefore, had been elaborately picked, and there was left suspended on the stake a skeleton dissected out and cleaned by many beaks with rare precision. The dazzling skeleton, complete and clean, was lifted on high . . . " and stealthily one night Vesalius removed it and conveyed it to his home. It is not improbable that the picture of that skeleton furnished the idea for the grave-digger in *Hamlet.*

Under such difficult circumstances a knowledge of human anatomy was born into the world. Vesalius paid the penalty of his rashness. He had to listen to the woes of the rich and powerful, for one thing: he was made court physician to Charles V. Later he was excommunicated; to lift the ban he went upon a penitential journey and we hear of him no more. But his work remains, *De Humani Corporis Fabrica* — "On the Fabric of the Human Body." Across the title-page of a copy of that book which he presented to a medical library, William Osler once wrote: "Modern medicine begins here." It was a long time to wait for a knowledge of the structure of the one object which is the most important and familiar to all of us. That knowledge is enshrined to-day in the minds and hearts of many men. And not the Church, nor the State, nor the universities, not all the powers of hell, nor all the agencies of Darkness shall prevail against it.

O yes! man's body has been a very useful accompanier of man's soul across the ages.

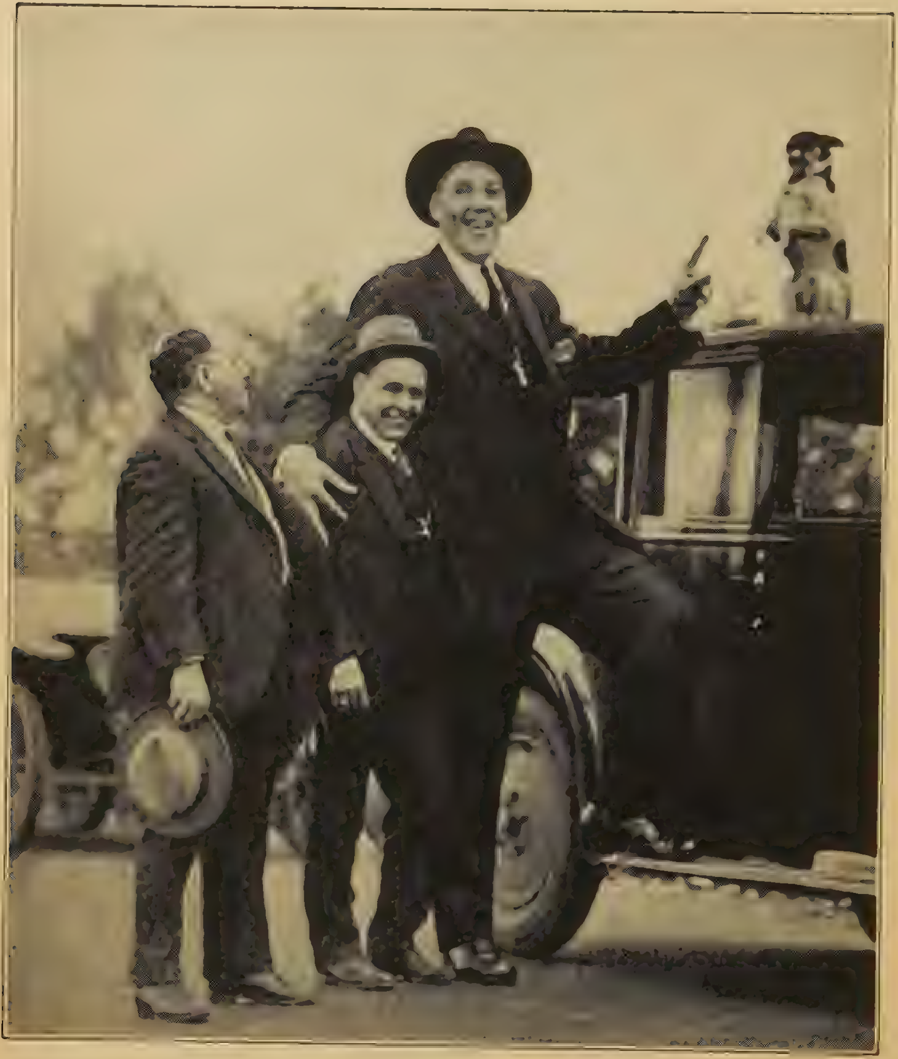


FIGURE 3

A giant. Unlike most giants, he is well proportioned. But he betrays the fact that he is an acromegalic giant by the size of his lower jaw and the size of his hands. Compare his hand with the hand of his average-sized companion. The giant is only one-third again as tall as the average man, but his hand is at least twice the size.

CHAPTER III

HEIGHT, WEIGHT, PHYSIQUE, AND SPAN OF LIFE

It will be profitable first to consider the human body in its entirety.

Taking a large group of men and women, we see that they have in the mass certain similar gross characteristics. The most extreme and exceptional variation from any one of these characteristics is really only very slight.

They all have a general size. In height the average adult male is 68 inches, the average female 65 inches. The smallest dwarf I find recorded (in Gould and Pyle's *Curiosities of Medicine*) was 18 inches high. The tallest giant was 108½ inches.

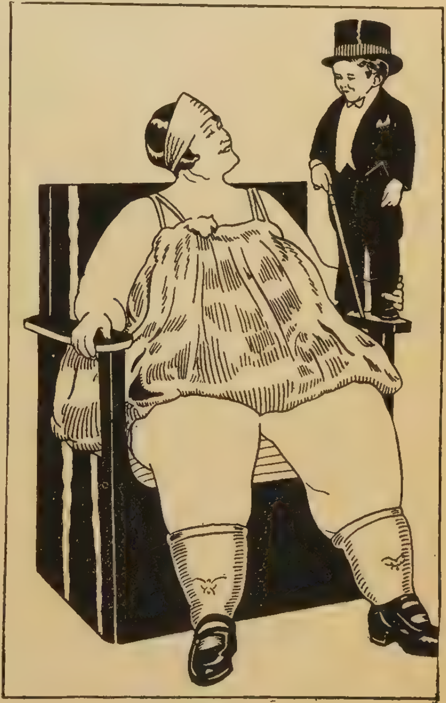


FIGURE 4

Extremes in the size of the human body. The world's "largest woman and smallest man." (From a photograph.)

Weight is dependent upon height, age, and sex. The average weight of the adult male may be said to be 150 pounds; of the average female 140. Edward Bright, "the fat man of Essex," weighed 616 pounds. Daniel Lambert, whose clothes were long on exhibition at Madame Tussaud's, and who was born in 1770 at Leicester, at 19 began to attain great weight and strength: he could lift 500 pounds with ease. In 1793 he weighed 448 pounds: he became very sensitive as to his appearance. In 1809 he weighed 739 pounds. Calvin Edson, a living skeleton, at the age of 42 weighed 42 pounds, was 5 feet, 4 inches tall, could chop a cord of wood without fatigue, and was the father of four children.

Human beings have also a certain general span of life. This was given by the ancient Jewish actuary as three score and ten years, and as that figure still remains, after perhaps three thousand years, at about the same point, we may feel that it represents an average of the species. To be sure we have the record of John Parr (examined after death by William Harvey), who was said to be 152 years of age when he died. Parr remained single until the age of 80. His first wife lived 30 years, and 8 years later, at the age of 118, he married again. After his death his second wife deposed that he performed his marital duties regularly for 19 years.

The record of Henry Jenkins, born in Yorkshire in 1501 and dying in 1670, is well proved. He remembered the battle of Flodden Field in 1513. By the register of Chancery Court it was proved he had appeared in evidence and had an oath administered to him 140 years before his death. In the office of the King's Remembrancer is the record of a deposition in which he appears as a witness at the age of 157. When over a hundred, he swam a river.

Not many years ago I saw, in an alms-house in New York, a feeble Jewish crone who mouthed for me her oft-repeated tale of seeing Napoleon ride through the streets of Moscow — "a black, worried-looking little man." But these considerations do not change our average. The variations, as you see, are within quite narrow limits. There are no real Lilliputians and no real Brobdingnagians, and no real immortals included in the human species.

Perfectly familiar as these facts are, their importance is nevertheless vital. They are of very considerable significance to every individual as regards both his future and his capacities. Any human being is definitely limited in his scope by the restrictions imposed by his body — by its size, its weight, its strength, the number of years it will continue to function. Our bodies are the traps in which each of us is caught.

Consider the question of longevity. Can anyone by taking thought or care add to his span of life? I do not think so. It is the custom of people who have attained an unusual age to grant an interview in which they record, doubtless in a kindly spirit, the reason for their advanced years. There is one peculiar fact about these dicta; no two agree. One nonogenarian proclaims that his continued vigour is due to a strictly vegetarian diet: another of equal age is quite vehement in advising the use of meat three times a day. Abstinence from alcohol plays a prominent part in a good share of these counsels; while a daily ration, probably considerably minimized in the memory of the narrator, seems to have done for an almost equal number. Granger twist, regular adherence to the Democratic ticket, total absentation from the polls, total immersion, the influence of Moody and Sankey, and the recollection of Della Fox are all included in the causes of longevity among the notes I have made from time to time upon this interesting topic.

Testimony of the most circumstantial kind in the matter of the influence of habits on longevity is available. There is the case of Thomas Wishart of Annandale, Dumfries, who died in 1760 at the age of 125. "He had chewed tobacco 117 years, contracting the habit as a child; his father gave it to him *to allay hunger* while shepherding in the Highlands." It is impossible to refrain from noting that his father was a Scotchman. William Riddell, who died at 116 years, "carefully avoided water all his life and had a love for brandy."

The fact is that the span of life of any individual is largely determined, barring accidents, at the moment when he starts off. Barring accidents, though, is a very important modification. Accidents include not only being hit by a Ford, but also being hit by a pneumococcus — that is getting pneumonia — or equally getting appendicitis or acquiring syphilis or getting in the family way or swallowing carbolic acid by mistake or intentionally (nature being quite impartial). These things excepted, the number of years a man or woman lives will depend upon the impetus which he or she received at conception, this impetus probably being largely the resultant of hereditary determinants. We say: "A man is as old as his arteries," and, certain reservations being noted, that is sound physiologic doctrine. But what causes arteries to harden? Many of my colleagues in the medical profession have been trying to show for many years the influence of various agents. They have not been able to convince even themselves. Favourites among the accused are alcohol, tobacco, red meat, and salt. Yet it must be plain to anyone, even to one who has had the disadvantages of a Harvard education, that people who indulge in all these ingredients freely go on to ripe old ages, and others who flee them religiously die of apoplexy and angina in a state of total decrepitude at the age of fifty-three.

An illustration from my own experience is amusing even if not final. Some years ago a friend of mine was greatly annoyed because his father-in-law at the age of eighty-three persisted in a lifelong habit of getting drunk; in fact, since he gave up active business, the old gentleman seemed to indulge more freely than before. On one or two occasions I rendered some service and became attached to the aged offender, a bright-eyed, quick, amusing old liar, who claimed to have witnessed personally every historical event from 1842 to the present date. He often told me of his younger brother, aged seventy-six, who lived in California, stating that this brother had lived a better life, having taken the pledge of total abstinence at the age of twenty-five. At last it was announced that the younger brother was arriving to pay him a visit and they came to see me at my office. They stood side by side and I turned my gaze from my erring friend, aged, remember, eighty-three, with his alert bearing, his beady, birdlike eyes, and his quick movements, to the brother, only seventy-six, who wore proudly on his somewhat spotted lapel the blue ribbon of the pledge. The total abstainer was a total physical wreck. His hands shook with a palsy, a film of cataract covered his eyes, and his hearing was almost gone, but as he was led, bowed and drooling, to a chair, he murmured to me that he ascribed his advanced age to his good habits in regard to the use of alcohol.

It is not meant to be implied by this that alcohol does no injury to the body. Certain definite diseases — cirrhosis of the liver and a form of neuritis or degeneration of the nerves — have been associated with it. They are, however, rather rare diseases and, in fact, usually met with only in large public hospitals; there seem to be secondary causes not certainly understood, possibly some deleterious products in cheap alcoholic beverages: there is even some debate whether these are not actually the ætiologic factors. Of a form of mania, delirium tremens, and death in it there is no doubt whatever that alcohol is the cause.

It may also be admitted that indulgence in alcohol totally unfits for first-class work, at least during the period of indulgence. The idea that Poe and Verlaine wrote their tales or poems under its influence is sheer nonsense. What is meant to be said here is simply the common observation that a moderate use of it, and even fairly immoderate use of it, are only rarely attended with serious physical consequences. Those lurid volumes, such as Victor Horsley's, which show the effect of alcohol on the body, with coloured pictures of hearts with fat tags hanging from them are thoroughly unscientific.

The question has been approached, indeed, by Dr. Raymond Pearl with the maddening calm which characterizes the methods of a mathematician (*American Mercury*, volume I, number 2, February 1924. Also, Pearl, *Alcohol and Longevity*, Alfred A. Knopf, Inc., 1926). He analysed a group of 1259 men and 788 women, divided into three groups — total abstainers, occasional drinkers, and heavy and steady drinkers. Dr. Pearl gives very good reasons for rejecting the experience of life-insurance companies in regard to alcohol. His cases were collected by social workers, and are not subject to those criticisms. He found that the duration of life in the three classes of those entering the experience at the age of 20 was:

	Males	*Females*
Total abstainers................	60.05 years	58.49 years
Moderate & occasional..........	61.04 "	61.70 "
Heavy & steady................	55.37 "	47.50 "

Attention is of course directed to the exhilarating fact that the total abstainers exist for a slightly shorter period than the moderate indulgers.

Let me make myself perfectly clear upon this point. I am not trying to furnish any material for propaganda in either direction. If a man resolves to abstain from alcohol, and even if he is passionate in his belief that that is the best thing for him and his labour, I am prepared to applaud him and avoid him. If, on the contrary, a man determines to go out on a spree and returns home and murders some woman with an intelligence quotient of 15, that also is a matter of utter indifference to me. Even if a person swallows a jug of synthetic gin and runs me down with his Ford, that too is a part of life, and I must learn to be spry and take care of myself on the streets. But what I most emphatically object to is the use of the sciences of physiology and pathology as handmaids to do the dirty work of prohibition agitators. Because the facts do not warrant any such interpretation. You may go into the library of the American College of Surgeons any day at the cocktail hour and ask the assembled fellows if they do not agree.

In the case of tobacco we have a fascinating comment made by Sir Marc Armand Ruffer in his book on the diseases of mummies. Ruffer occupied the chair of pathology (the science of disease) in the medical department of the University of Cairo, and he became much interested in the examination of mummies, finding that he could often make a diagnosis of the cause of death from the tissues preserved. Diseases in the bones were, of course, quite plain, but, just to illustrate how far he could carry his diagnosis, he tells us that he could remove tissue, cut it and stain it as is done for an ordinary microscopic examination of fresh tissue, and distinguish under the microscope liver from kidney. The cells were still faintly recognizable after three thousand years. He frequently found arteries in these mummies that were sclerotic, or, as it is popularly termed, "hardened," and he makes the illuminating comment that, whatever else this process was due to, it was not caused by tobacco or syphilis, both of these being contributions of America to European civilization (syphilis was probably imported into Europe by Columbus's sailors; the history of tobacco is well known). Ruffer states further that he frequently held postmortems on Arabs who were the strictest of Mohammedans, so that he felt perfectly certain that they had never taken a drink containing alcohol from the day of their birth to that of their death; the incidence of degeneration of the arteries was just as great with them as in his previous experience with Europeans.

Here again we must be careful to get all the facts. Tobacco has quite easily measurable physiologic actions. Principally these are a constriction of the blood-vessels, through their muscular coats, and a rise of blood-pressure. When changes have definitely occurred in the arteries and a condition known as angina pectoris, which is pain around the heart, probably caused by spasm of the arteries supplying the heart-muscle, exists, tobacco often augments the pain and should be stopped. But that does not mean that it *causes* the arterial change. And that it is responsible for tuberculosis, or dyspepsia, there is no evidence whatever.

Exercise and fresh air are supposed to be the sovereign augmenters of long life. I admit that they make one feel better. That they promote longevity I seriously doubt. I instance two famous examples — Theodore Roosevelt and Walter Camp, both advocates and practitioners of regular daily outdoor exercise, both dying in the early sixties. On the other hand, everyone knows a dozen octogenarians who have never taken a day's exercise in their lives.

No, much as I might like to believe it, happy as I should be to follow dietary and ethical restrictions if I were convinced of their validity, an impartial examination of all the means yet proposed to prevent early death or lengthen life leaves me with the conviction that nothing anybody does to himself after he is born makes more than a few hours' difference at the most.

The combination of weight and height results in a general build of the body which may be called *habitus*. If you will classify all the people you see in a crowded room on the basis of general body contour, you will find that you have three general divisions — thin ones, heavy ones, and medium ones. If the crowd is large enough, you can range a line of them from the long, thin greyhound type at one end to the broad, stocky Clydesdale at the other, the difference between any two individuals in the row being almost imperceptible.

The difference between a thin and a heavily built person is, however, far deeper than the surface, and those differences have great bearing on their health and disease proclivities. Figures 5 and 6 show extreme examples of torsos of both types, with the internal organs indicated as they were shown by composite X-ray photographs.

Compare them carefully. Notice first how the ribs flare out from the midline at the junction of the chest and the abdomen. In the thin person this angle is very narrow, in the heavy one very wide. This so-called "costal angle" is a rough index of the type of individual with which you are dealing. Notice the comparative chest size. The thin type has enormous lungs, more than he needs for his nutritional needs, so that air does not blow in and out of all his lung spaces, and these people are peculiarly liable to tuberculosis: it is, when you think of it, a typically "consumptive"

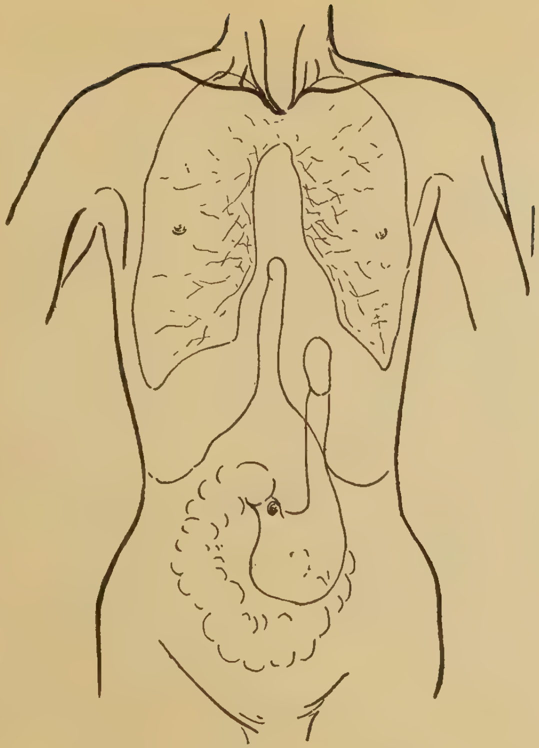


FIGURE 5

The carnivorous or asthenic type of body. (After a figure by Dr. Walter Mills.) Drawn from a composite of many X-ray photographs.

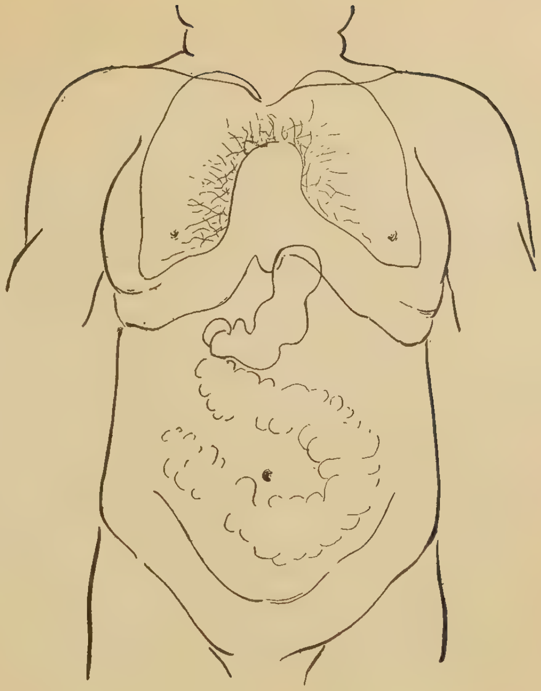


FIGURE 6

The herbivorous or sthenic type of body. (After a figure by Dr. Walter Mills.) Drawn from a composite of many X-ray photographs.

build. The heavy one, on the contrary, has very small lungs, and because he does not regularly breathe in and out a good oversupply of oxygen to burn all the food he eats, it accumulates in the form of fat, and this may have something to do with his obesity. Notice the two hearts, and the main blood-vessel coming from the heart, the aorta. In the thin one the heart hangs dependent, with a long, elastic aorta; in the heavy one it is squat, with a short, wide aorta. The thin ones seldom have heart or arterial diseases, and if they live past youth, the period of tuberculosis, they are likely to live for ever: notice that at least 60% of very old people are of this type. The heavily built, on the other hand, for some reason that is not certainly determined, appear to have associated in their germ plasms a tendency towards arterial degeneration and high blood-pressure with their stockiness; life-insurance companies shy away from overweight risks. This tendency is crystallized in the common exclamation: "He looks as if he might be going to have an apoplexy." Much more significant and regular in occurrence than any of these is the architecture of the digestive tract in the two types. The stomach of the thin one is long and drooping: the outlet of the stomach, the pylorus, is held high (by a strong and constant ligament) and there is some mechanical difficulty in getting a meal moved up from the low-hanging stomach out into the intestines. Hence these people are likely to have a heavy feeling and gas after eating; if you come to think of it, they are also the typical "dyspepsia" type. For the same reason that the stomach hangs low — on account of the long abdomen and the thin abdominal wall, unbuttressed by a layer of fat — the intestines sag, and especially the large intestine: they are likely to be constipated and augment this tendency by consuming cathartics. The heavier one scores on this point: his stomach is small and high placed and empties easily; hence he enjoys the happiness of the table, is an epicure; and this really adds to his tendency to overweight. For this reason also, as life goes on, his islets of Langerhans become sclerotic, which gives him a tendency towards diabetes. His intestines are high, supported by thick abdominal walls and intra-abdominal fat, and he is seldom constipated. Thus each has his tendencies, his dangers, and his distresses.

But there is further a mental view-point, a disposition, as we say, which goes with each type. The thin one, because his muscles are long and slender, because his digestive tract is poorly upheld, is easily fatigued. But he may be just as ambitious as anyone else. He is constantly laying out programs for himself that he cannot carry through. This breeds melancholy and dissatisfaction. The heavy ones are much more likely to be able to accomplish their tasks easily. So they are cheerful, jovial, get through their work in a few hours, look back on it with pleasure, and are ready to begin a party at half past four in the afternoon. They like marriage feasts and christenings. The thin ones like divorces and funerals: you will find them comforting the misunderstood wives or arranging the flowers. The heavy ones like poker; the thin ones solitaire. The heavy ones are interested in getting just the right flavour to their cocktail; the thin ones in getting the most potent fluid extract of cascara. The heavy ones read Eddie Guest, Conan Doyle, and the *Saturday Evening Post*; the thin ones Baudelaire, Dostoevsky, and the *Dial*. The thin ones are always starting out to reform something; the heavy ones have found that it saves trouble to subscribe to the cause right away and take no further part in it, knowing from experience that the thin ones will not have the endurance to carry the reform to any uncomfortable extreme.

These things are said, of course, in a very general way. There are, it is acknowledged, plenty of exceptions. But let it not be supposed that there is not abundant evidence for the statements made. Indeed, a recent author, Dr. George Draper of New York, in a book entitled *The Human Constitution*, which is quite as brilliant in its own *métier* as is *Dorian Gray* in its, has gone far beyond any of my tame statements. He has made careful measurements of all kinds over thousands of bodies — such as the angle of the jaw — the gonial angle. He makes statements tending to show that a certain type of individual is disposed towards gall-stones, while a different type is disposed towards ulcer of the stomach — and that the gall-stone individual will seldom have ulcer and that the ulcer people seldom have gall-stones. There is a pernicious-anæmia type of face, an asthma type of face, etc.

And all of these statements are fortified by table after table of exact measurements, collected in the most painstaking fashion by a conservative and scientific physician.

In the words of Sir Arthur Keith, who writes an introduction to the book, Dr. Draper "seeks to link up the machinery of growth, the machinery which gives the human body its shape, texture, and constitution, with its liability to disorder — to disease." As the title of his book implies, he has laid a scientific foundation for that idea which we young fellows used to laugh at so hard, that the family physician was the best man to call in because he understood his patient's "constitution."

What can be done to help guide a constitutionally thin or heavy person past his dangers? Considering the inherent difficulties of the task, a good deal. For the ones we have called the thin people — other names have been given them, as carnivorous, asthenic, hyperontomorph, linear — they should sooner or later be brought to a realization of the very important fact for them that they have not the same powers of endurance as other people with stronger structures. This sounds very logical as put down here, but it is astonishing how long it takes some of these people to come to this conviction, how much turmoil they go through, how many diagnoses are pronounced upon them. My colleagues in the medical profession have been very slow to grasp this idea of the whole man. It is, along with another matter which I shall speak of in the chapter on the relation of mind to body, the greatest reproach which, I believe, can be laid at their door in modern days. Because the patient complains of a pain in a particular spot — say the stomach — doctors are apt to concentrate their attention on that spot and make a diagnosis of ulcer of the stomach or gallstones, or atony of the stomach; or, if the patient complains of backache, they diagnose lumbago, or focal infection, or scoliosis. They see the little area where the symptoms are and miss the sight which is always so difficult to get just because it is so obvious — they miss the whole person. The matter of diagnosis, then, should be emphasized because it is both so often wrongly conceived and so primary a consideration for treatment.

Rest for certain periods in the day sufficient to renew the stores of energy which these bodies need is the first element in treatment or adjustment. When leisure permits, they should rest on a bed or a lounge — i.e., in the recumbent position — for half an hour to an hour after each meal. The time after meals is selected because the recumbent position helps the mechanical difficulty under which the stomach ordinarily labours — it brings the low part of the stomach upwards, and facilitates easier emptying. But rest itself is necessary. Dr. Bryant, who conducts a large charity clinic of these patients at the Massachusetts General Hospital, has found, because his patients are under heavy economic necessity, work hard and continuously, and would scorn the idea of lying down an hour after meals, that if he can get them to rest, lying down at complete relaxation, five minutes out of every hour, they can in that way get along very well.

Other accessories to treatment are exercise to strengthen the abdomen — lying on the back and raising the legs to a vertical position — the wearing of supporting corsets, and an increased diet to fatten them up. When they reply, as they usually do, that they do not eat because they have no appetite, the answer may be: "An appetite is a luxury, not a necessity." A person can eat without appetite. The hopeful thing about them is that as middle age comes on and their supporting ligaments become stiffer, and the stresses of life fade, they will get more and more confortable and will begin to expatiate on the way of life they have led as an aid to longevity.

The heavy ones — who have been called also herbivorous and hypersthenic and the lateral type — must also adjust their way of life to the form of their body. They must learn to be abstemious at the table, they must renounce the limousine, and walk and exercise. The story for them is of the Epicurean philosopher who starved himself for three days in order that he might have the exquisite pleasure of gnawing a stale crust of bread. The trouble with them is that they enjoy existence so much that their fate is upon them before they begin any restrictions. For them, as for the thin ones, their way of life must be a lifelong task.

CHAPTER IV

HEREDITY AND ENVIRONMENT

Such considerations — that different individuals are endowed with different styles of bodily architecture, and that these dispose them somewhat fatalistically towards certain disease tendencies — lead us to make a very natural inquiry. What healthy functions and what disease processes are planted in an individual by inheritance, and what disease processes are due to his contacts and his way of life? In short, what comparative influence have heredity and environment?

The relative roles of heredity and environment in shaping any individual's bodily architecture, in influencing any individual's methods of function and activity, and in determining any individual's destiny and frustrations, are problems that have been expounded through many tracts. I shall attempt to draw attention to a fresh point of view of the subject. It may perhaps best be approached in terms of mathematics.

In 1850 a new-born human being had a life expectancy of 35 years; in 1925 a new-born human being had a life expectancy of 55 years. In 1850 a human being who had reached the age of 35 years might expect on the average to live twenty-five and three tenths years longer; in 1925 a human being who had reached the age of 35 years might expect on the average to live twenty-five and four tenths years longer. These figures are of course general actuarial estimates. They apply to large groups of people, not to any one person. In other words, they state that if a thousand new-born babies, representing all economic and social classes in the population, from the mansion to the tenement, were followed until they all died, the sum of the years that thousand babies would live would be, in 1850, 35,000 years; in 1925, 55,000 years. And if a thousand men and women, representing an equally variegated cross-section of the population, were grouped at the age of 35 and followed until they all died, the sum of the years they would live would be, in 1850, 25,300 years, and in 1925, 25,400 years.

What do these facts mean? They mean that, so far as the dangers of his body are concerned, man has conquered his environment, and that so far as the dangers of his body are concerned, man is still as much (disregarding the probably adventitious difference of one tenth of a year) at the mercy of his heredity as he was in the stone age. The improvement of twenty years in the life expectancy of a new-born baby represents man's conquest of the infectious diseases, his control of bacteria: more than anything else it is a saving of infant mortality. The figures mean that he has learned how to keep milk clean, how to supervise the inspection of other foods given to infants and children: they mean that he can prevent smallpox and diphtheria, and typhoid fever and scarlet fever, and, to a large extent, tuberculosis.

These are plain facts. They admit of no other interpretation than those which I have imposed upon them. No other interpretation except this — that if large groups of the population were not still ignorant and suspicious and stupid, life expectancy for the new-born could still further be lengthened, and infantile dysentery, diphtheria, smallpox, typhoid and scarlet fever could be wiped from the face of the earth.

Here we grapple with a very curious psychological phenomenon. It is not easy to understand. It is not even easy to state. It may be put in the simplest terms by saying that people in general are suspicious of the recommendations which the physician makes to them about the protection of their bodies from their environment, and yet seem willing to try anything to influence those diseases or body tendencies which are dependent upon their heredity. To make the point specific: a given person who is going to Egypt is advised to have typhoid prevention; it is explained that this is accomplished by injecting three hypodermics of typhoid bacilli under his skin; it sometimes takes a mental wrestling-match of hours to induce him to allow this harmless and effective procedure to be carried out: he doesn't like the idea of something injected into him, especially bacteria; he is unconvinced by the evidence; he is doubtful of his danger. Yet what you are offering him is one of the conquests of man over nature — one of the greatest of those conquests: what you are offering him is the garnered fruit of the painful experience of man's journey through the ages. And this same individual may even at the moment be taking treatments to prevent his approaching baldness, which beyond all peradventure is an hereditary condition. He may be sitting in chairs with snake oil and violet lamps playing all over his head, when the only way to cure his baldness would have been to castrate his grandfather. He may be taking treatments for the relief of high blood-pressure, which also is an hereditary condition and marches its forward way irrespective of treatment. What won't he do for that when he finds out about it? *Then* he has no fear of injections — radium in the vein, electricity shooting about, sitting in a chair with magnetic currents going all over him, hurrying as fast as he can to some new place where some new and more painful and queerer treatment can be given him.

I say these things with heat. It is characteristic of the weariness which besets men who see how unwilling mankind is to apply the wisdom which the long struggle of the ages has painfully assembled. Professor Robinson in *The Ordeal of Civilization* has expressed the same impatience:

"Men have hitherto ill understood themselves and their world. They have not only suffered from blank ignorance but from tremendous and grotesque misapprehensions in regard to their nature and surroundings. Whether they can ever learn enough to control the fluctuations of civilization no one can say. So far it has certainly been drift rather than mastery. The best knowledge of man and his world which is now scattered about in the heads and books of those who have taken the most pains to inform themselves is incalculably greater than ever before in man's history. It is this knowledge, called 'science,' and its applications which constitute the distinctive trait of our present civilization.

"Its steady progress is by no means assured."

That last sentence is impressive. It is idle apparently to point out that it is easier to influence those conditions which are acquired than it is those which are inherited. For instance, falling on the ice and breaking a leg is an acquired condition; a tendency to bear twins is notably an inherited characteristic. It is much simpler to mend the fracture than it is to prevent the bearing of twins.

The great failures of medicine in the domain of therapeutics (the art of cure) have been with diseases that are hereditary or possibly hereditary. Its great successes have been with the diseases which are acquired, and due to environment.

Yet this principle does not inevitably hold. Nothing is more certain than that hay-fever is hereditary. Yet medical science is able to prevent hay-fever in a quite respectable proportion of cases.

Let us examine briefly one or two of the features of both heredity and environment as they might affect a human organism. First, some of the things which we know about such an organism's reaction to its environment.

The most important of the conditions which affect the body after birth, or at least after the fertilization of the ovum, and thus are not hereditarily laid down in the germ plasm as tissue tendencies, are the infectious diseases. All germs or bacteria enter the body after birth or after the fertilization of the ovum, and all the protective reactions of the body towards the growth of bacteria are acquired by the individual and none are inherited. All immunity is contact immunity. It may be well to pause and examine these statements, as they run counter to several widely held beliefs. Examples of such beliefs are found in the phrases "inherited tuberculosis" or "hereditary syphilis." In the case of tuberculosis what is inherited is a bodily build which seems to furnish a favourable field for the development of tuberculosis; but there is no good evidence that the tubercle bacillus ever enters the body before birth. In the case of syphilis it is proper to speak of congenital syphilis but not of hereditary syphilis; the parasite which causes syphilis entering the body of the developing child in the womb, from the mother's blood, the child being infected with syphilis at birth.

The fact that all immunity is contact immunity is even more surprising, but nevertheless true. There is probably no such thing as natural immunity, though there may be rare exceptions to this; Osler mentions the case of Diemerbrorch, a celebrated Utrecht professor in the seventeenth century, who was exempt from smallpox, as were many members of his family; and racial immunity to some infections, such as the American Indian's immunity to scarlet fever, appears to be proved. Certain parts of the work of Park and Zingher of the New York Health Department in examining school-children for diphtheria illustrate well what is meant by contact immunity. Several years ago there was brought out the Schick test, which will determine whether or not any individual is immune or susceptible to diphtheria. The test is made by injecting a small amount of the toxin of diphtheria into the skin; if the person tested is susceptible to diphtheria, a small red area appears at the site of injection in about twenty-four hours; if the person tested is immune, no redness appears. When many thousands of individuals of all ages are tested, some very interesting results appear. Up to the age of three months, only about 15 per cent of babies show susceptibility; i.e., only fifteen out of a hundred will catch diphtheria if exposed. Which means that the others have acquired immunity from the mother's milk or from the mother's immune bodies in her blood transferred to the developing child in the womb. After the age of three months this mother-got immunity rapidly disappears, so that at one year of age, 60 per cent show susceptibility. This figure holds up to the age of about three to five years, when the rate of immunity begins to increase, susceptibles being 40 per cent at five years, 30 per cent at ten years, and 12 per cent at twenty years. These facts are easily verified by personal experience; if you will try to remember the cases of diphtheria (or measles or scarlet fever, which act on the same principle) which have occurred in your own experience, you will recall that most of them occurred in children, and the incidence of the cases diminished among adults.

How do people who never had diphtheria itself acquire their immunity? Dr. Park and Dr. Zingher found some very suggestive facts on this point. If they examined a school in the crowded tenement district, the number of children immune to diphtheria would be about 60 to 80 per cent. When they examined the children in a private school, the immunes would be only 20 to 30 per cent. What is the cause of this big difference? The children in the private school were usually brought there by chauffeurs, their desks were a good distance from each other, after school was over they usually were taken back home, where a minimal amount of objects contaminated by the unclean world were found, and they slept in a room either by themselves or at most with one or two brothers or sisters. The children in the tenement-district schools went there in crowds, after school they went back to buildings where hundreds of people passed up and down the stairs they sat on, people coming from all sorts of places, and they slept in rooms where ten is considered the logical number of bedfellows.

Thus, little by little, they took in a few straggling diphtheria germs, some of them dead, some of them almost lifeless; and each time, they developed a part of those chemical reactions in the blood which we call immunity. Their immunity was contact immunity. They had gradually vaccinated themselves against diphtheria.

The medical profession is able to produce immunity to many diseases by imitating this principle — to smallpox, to typhoid fever, to diphtheria, to scarlet fever, to hydrophobia, and to lockjaw notably. For diphtheria, meningitis, and scarlet fever we have serum which, in a high percentage of cases, will cure after the disease has been acquired. In other diseases — notably those due to parasites — malaria, amœbic dysentery, and some of unknown ætiology spread by mosquitoes and other insects — yellow fever, bubonic plague, and certain tropical diseases — the means to prevent, and after they are acquired to cure, are in our hands.

Over the entrance to the scientific exhibit of a certain exposition, a few years ago, a banner was hung bearing these words of Robert Koch:

"It is possible for man to banish all infectious diseases from the earth."

They are great words. How many people believed them? How many at that exposition even tried to understand them? The banner fluttered gaily in the summer breeze for a time, it became drenched with the summer rains and torn with the summer winds, and the dumb crowd passed it by, the light of exploitation in their eyes. They had been told that a Hindu was going to grow a banyan-tree in five minutes and climb up to the top of it and disappear. This was to happen in the next street. So they did not read the words upon the rain-soaked banner.

People differ widely in their reaction to the question of heredity. Some are inclined to ascribe many of their ills and characteristics to inheritance; others pooh-pooh any such notion. Some ascribe many of their ills to family legacy, and stoutly resist the idea that others are so ascribable. Yet in both instances they may be wrong. For instance, a given individual may be rather proud of the idea that he inherited a "weak stomach," but stubbornly convinced that his increasing baldness is due to putting water on his hair in youth. Yet the weak stomach might be due to the fact that one parent was a neurotic dyspeptic and that all through childhood a mental pattern of the central importance of the operation of the digestive tract was beaten in so that in times of stress or failure (subconsciously), or as a mode of occupying the limelight in after life, "My weak stomach, you know — Father had a weak stomach — it runs in the family" is paraded forth; in other words, the weak stomach may be no more than an accident of contact in early life.

Baldness, on the contrary, is, as a matter of the most common observation, strictly an hereditary condition. (I mean common or garden baldness, not *alopecia areata*.) Furthermore, it appears to be inherited only, or nearly so, in the male line; that is, from father to son, not from father to daughter and not from mother to son, females being very resistant to its inroads. No one who has lived for any length of time, say to the age of thirty-five, can have helped seeing one friend who begins at about the age of twenty-seven to observe wads of hair coming out on his comb. Anyone with half an eye can see that his father, or an uncle, is as bare as Phryne on the top of the head. Everyone but the victim sees the inevitable. Yet nothing seems so difficult as to convince one of them that hope is gone. After consulting a regular dermatologist who tells him there is nothing to do, he begins a frantic round of treatments by barbers, scalp-treatment parlours, drug-store remedies, and dandruff cures. He becomes a peerer from unnatural positions into mirrors. There is more joy over one spear of delicate down than over ninety and nine racoon coats. Finally the long struggle ends — at about the age of forty. A nude swath extends from the eyebrows to the external occipital protuberance, the beauty parlours see him no more, and he begins to worry about some dignified way of keeping flies off the sensitive skin covering his calvarium. The unforgettable picture of the brothers Bryan photographed in their skull-caps illustrates the common ancestral quality of the condition.

Note that the degeneration of the hair follicles on top of the head is laid down in the germ plasm to begin at a definite time in life. It is held off in youth and has a characteristic age onset. This is a feature of other hereditary diseases that come on in late life, which makes it difficult for people to believe that they are inherited. They get a notion that if a disease is hereditary, it should show up at birth.

I said above that by *baldness* I did not refer to *alopecia areata.* It may be well to explain what I had in mind. I have no doubt that some who read my description will recall those pictures in drug-store windows which are advertisements for a baldness cure, and will use them for a refutation of my argument. The pictures usually represent a man at the date of, say, 1920 without a spear of hair on his head, side by side with a picture of the same man in 1924 after he has been using the baldness cure, his head covered with a luxuriant growth of fur. These are almost invariably examples of *alopecia areata*, the characteristics of which disease are that all the hair on the head suddenly falls out, and after a lapse of from three months to a year begins to grow back in, until completely restored.

When human heredity is under examination, it is well to remember that it is one of the most difficult of all subjects about which to collect data. What we know about heredity has been learned in plants and lower animals, by breeding-experiments. For the study of human heredity breeding-experiments are taboo. Even if they were not, it took Maud Slye five generations of mice to produce cancer mice. Five generations would carry an adult living to-day back to 1750. How many people know fifty per cent of all their ancestors living in 1750 well enough to know not only what diseases they died of, but what diseases — such as asthma or eczema or wide incisor teeth — they carried in life?

The science of heredity must explain not why a tall man on the average has taller children than a short man, but why if all the sons of a number of tall men were measured, it would be found that they showed every gradation in height; why if a tall man marries a short woman, the sons are neither as tall as the father nor divided sharply into a tall group and a short group; why, on the contrary, if a tall variety of sweet-pea be crossed with a dwarf variety, all the offspring of the first generation are as tall as the tall parent and from the second generation some of the offspring will be tall and some dwarf, but none intermediate in height; why if a white rabbit be mated with a black one, sometimes all the offspring will have the grey-brown colour of the wild rabbit and sometimes all the offspring will be black; why if you mate these grey-brown rabbits, or the black rabbits which are the offspring of black and white parents, some of their children will be perfectly white (the white colour skipping an entire generation and reappearing in the grandchildren); why in man a colour-blind father rarely has colour-blind children, but some of his nephews and male grandchildren through the female line are usually affected, the disease appearing only in males, transmitted only through females.

I emphasize these things because I do not wish to cause anyone unnecessary apprehension; and in the diseases which I speak of below as possibly or certainly hereditary it should be remembered that human heredity, because of the great confusion of intermarriages, is very uncertain and that no individual can predict anything about himself. In my own case, for example, both of my parents are living over the age of seventy; two of my grandparents died of infectious diseases before they were old enough to develop any degenerative diseases of middle or old age; one grandparent died at the age of sixty-three of a degenerative disease (angina pectoris), due to sclerosis of the arteries, and one died at fifty-six of cancer. What is waiting round the corner for me? I have no idea. I may be hanged. But I have no data to do any worrying on.

In so short a volume as this there is no space to present a summary of the knowledge which biologic science has accumulated about heredity. It is one of the most complete departments in that science. One or two fundamental points I will make here, referring those who wish the experimental proof upon which they rest to any number of books, one of the soundest of which is Conklin's *Heredity and Environment* (Princeton University Press).

I assume in the first place that everyone is familiar with the fundamental biologic doctrine of the continuity of the germ plasm. That is the first law of heredity — that hereditary characteristics are held in trust in the germ-cells, that these are not influenced by anything which happens to the soma or body-cells. For instance, you can cut off the tails of mice for a thousand generations, but still in the thousand-and-first generation the baby mice are born with tails. The Jews have practised circumcision for forty centuries, but still Jews are born with prepuces.

These phenomena of the stability and transmissibility of congenital somatic characters form the basis for the breeding of great varieties of plants and animals. The productions of Luther

Burbank were evolved on this principle; the enormous variation in the dog brought about by breeders through thousands of years and resulting in the greyhound, the St. Bernard, the bulldog, the Mexican hairless dog, and the Pekinese has all been accomplished on the same principle. But it is not only anatomical characters which are inherited, but physiologic ones also. I have put the tip of my little finger in the mouth of a new-born baby, one second old, at least a hundred times. As soon as I do so, the little lips and tongue curl around my finger and it begins to suck; a few days later it will be sucking milk from its mother's nipple; but that sucking instinct exists the first second it is born. Why? Certainly no one could have taught it to perform sucking motions. It seems to me the logical explanation is very simple. If a baby were born without the sucking instinct, it would shortly starve to death. It would therefore become the parent of no other human beings. All non-sucking humans die off. Thus the sucking instinct is transmitted as an hereditary protective device. That is what I meant in my original definition by saying that the human body was fitted for its functions "by the processes of selection and evolution." Take another illustration of a physiologic trait. The blood coagulates or clots or hardens as soon as it reaches the air. Why? In order that if a blood-vessel is severed, the clot will cork up the cut end of the vessel and prevent all the rest of the blood from escaping from the body. If that ability to coagulate were not born in the blood of an individual, he would not live long. Hence the coagulability of the blood is an hereditary characteristic fostered and formed by natural selection. There is in fact a disease, hæmophilia, in which the coagulation time of the blood is greatly prolonged; it does finally coagulate, but it is after a long time and extensive hæmorrhages have occurred. Most individuals who have it do not live long enough to breed: the disease is getting to be very rare. Only those hæmophiliac individuals who are carefully protected survive.

The second great principle of heredity is associated with the name of Mendel and is concerned with the segregation of inherited characters. Select one kind of an inherited character and its opposite — whiteness and blackness in the fur of a rabbit. If you mate a white rabbit and a black rabbit and if they have enough offspring (which latter as a matter of tradition for rabbits seems an easy assumption), those offspring will occur in the following proportions:

One white rabbit.
Two brown rabbits.
One black rabbit.

If the white rabbits are always bred with white rabbits, the offspring will always be pure white. If the black rabbits breed with black rabbits, the offspring will always be black rabbits. If the brown rabbits are bred, the progeny will result on the average in

One white rabbit.
Two brown rabbits.
One black rabbit.

The characters of black and white and brown, called unit factors by biologists, are inherent in some mysterious way in a speck of the protoplasm of the germ plasm of the parents — in the chromosomes of the nucleus of either the ovum or the sperm.

The characters white and black, because they appear in a smaller proportion of instances than the brown character, are called recessive; the brown is dominant. This is a very important generalization, especially for disease unit factors. I emphasized that "*if there were* enough progeny," the proportion of one white, one black, and two browns held; but this is only true if the progeny reaches the thousands. A unit factor such as a disease which happens to be a recessive character may not appear for one or two hundred individuals, which may be a period of several generations, and then suddenly appear fully flowered in the body of some unfortunate person.

When we select two hereditary characters, such as whiteness and smallness of size as against blackness and largeness of size, we find that, if we have enough progeny, they will occur in this proportion:

One small white rabbit.
One large white rabbit.
Two small brown rabbits.
Two large brown rabbits.
One small black rabbit.
One large black rabbit.

In short, one single character will act just as any other single character as to frequency.

But when we deal with more than two or more than three characters, or when we deal with groups sometimes even as small as two, we are likely to run upon a new and different rule. It is that certain characters tend to group together and be transmitted together. For instance, in the fruit fly *Drosophila*, which has been studied very extensively in experiments in heredity, it has been found that certain spots, length of wing, shape of wing, etc., are grouped so that, for instance (these words won't mean anything to you unless you are familiar with the anatomy of *Drosophila*), *yellow scute*, *brood*, *cut wing*, *bar eye*, *miniature wing*, etc., tend very strongly to go together and that other characters tend to go together in other individuals. Four of these groupings have been made out for *Drosophila*, and Morgan and his associates have shown that they are located in four certain chromosomes in the germ-cells (an almost magical piece of prying into nature's secrets).

Students of human anatomy, human physiology, and human pathology have been curiously blind to all the work done in the field of heredity. Why I do not know. But it is certainly true that from medical literature you would hardly discover that any such knowledge exists. One would suppose that no diseases obeyed the laws of heredity at all. But such is not the case. There are many unit factors which are disease factors — many more I believe than pathologists generally recognize. Animal experiments in heredity can be carried on with diseases as the units to be observed.

Certain human diseases are so strikingly bizarre in themselves that they have been easily seen to be hereditary. One of these has just been mentioned — colour-blindness. Another is a tendency for the blood not to coagulate — hæmophilia — the patients are called bleeders — it is transmitted only through mothers and only to sons. Feeble-mindedness is notoriously hereditary, as witness many notable studies, particularly those of Goddard, Dugdale, and Estabrook. Many other diseases which are very common, which appear suddenly in adult life or in late middle age or even in old age, have been intensively investigated by all the means at present at our command — the chemical laboratory, the microscopic study of tissue, the bacteriologic laboratory, etc. —

without yielding any real information about their cause or nature. There is coming about a strong belief in many minds that these are hereditary and due to a tendency laid down in the germ plasm for certain bodily tissues to develop along certain lines beginning at a certain time in life.

High blood-pressure, or hypertension as it may be conveniently called, has been investigated very intensively to determine its origin. To some of these investigations I have already alluded — i.e., the determination to make out a cause in the use of alcohol, or red meat, or tobacco, or salt, etc. Most work on the subject, however, fails of complete verification because it does not take into account first the exceptions (the many cases of hypertension, for instance, among people who never use alcohol) and secondly because none of them account for its occurrence in late life. It is distinctly a disease of senescence. Yet curiously enough every once in a while we find a comparatively young person with a true case of hypertension, dying of old age at thirty-five years. In such a case the whole family history is riddled with apoplexy, Bright's disease, sudden death, and heart-failure. Never, however, do we find a very old person with an unusually high blood-pressure. Physicians are acknowledging the hereditary nature of the condition: Mortensen (*Journal of the American Medical Association*, volume 85, number 22, page 1696, November 28, 1925), after a careful review of a large number of cases, concludes that it is definitely hereditary and that an abnormal associated functional habit of breaking up the meats and albumin in the body is also hereditary.

Think of what Maud Slye did with cancer in mice. She has been selecting out mice in which cancer occurs spontaneously and inbreeding the cancerous stock for twelve years. She can not only breed mice which will die of cancer in a definite mathematical proportion (one out of eight), but she can breed mice which will develop cancer of a particular part of the body. You write to her and say: "Send me two dozen mice which will develop cancer of the liver," and along they come and by and by begin to die off of cancer of the liver. In certain of her litters every mouse has died of cancer. The susceptibility to cancer acts as a Mendelian recessive, the resistance to it as a Mendelian dominant.

Can anything be done to escape these hereditary tendencies?

Yes, certainly. We have the knowledge — the knowledge of the science of heredity — and the method, if we wish to apply the method. It simply means the elimination of the thing called love as it is concerned in the selection of a mate for marriage. Or it means the elimination of the method of selection by the parents of the prospective candidates, as practised by the French and other savage tribes, on the basis of the social and economic factors involved, to the exclusion of the physical characteristics of the two individuals. It means giving up any smug and tacit pretence that marriage in the vast majority of instances is entered into for anything else than to beget progeny.

Now, of course, I'm not a fool. This statement will probably cause more dissent than any other one in this book. But nevertheless it is true. I repeat, I am not a fool. I know perfectly well that no such arrangement as I have implied above is going to be brought about. Men are not going to embrace eugenics. They are going to embrace the first likely, trim-figured girl with limpid eyes and flashing teeth who comes along, in spite of the fact that her germ plasm is probably reeking with hypertension, cancer, hæmophilia, colour-blindness, hay-fever, epilepsy, and amyotrophic lateral sclerosis. This represents a deep piece of sardony on the part of nature: I do not believe she ever intended man to become a long-lived race. It is an actual fact that those people who have all of these terrible excrescences ready to break out are in youth the loveliest of the sons and daughters of men: they are charming, jovial, fun-loving, laugh-provoking, filled eternally with a kind of divine ecstasy; and then their bodies — there is a sort of ethereal transparency to their skin, there hangs about them an unearthly — well, I mustn't go on like this.

But if we could disregard love, disregard physical attractiveness — if I had the power to breed men and women as I liked, I could, in about five centuries, produce a race of men whose average duration of life would be two hundred and fifty years, and another race who would die of senility — bald, toothless, and blind — at the age of fifteen. I could produce a race of tall, enormously strong, shaggy-haired men, and another of small, shy, absolutely hairless men. I could produce a race of women who would have a long purple plume growing from their foreheads, and hanging to their heels, and a race of men with two enormous bright scales over their ears. Perhaps it is well that no such power can ever be delegated to any man. People are funny enough as it is.

"Is this then all?" as someone remarked on some historical occasion. Can nothing be done for the people who are actually in the land of the living? Perhaps a little. That one tenth of a year increase in life expectancy for the individual who has reached 35 probably means something — diet, exercise, baths, rest-periods, no strain, etc. If you follow very carefully the dictates of the Life Extension Institute, you can live on the average one month longer than you would otherwise. Which period you will spend in bed flat on your back, giving explicit instructions to the nurse as to whom you want for pall-bearers.

NOTE: The figures used in this chapter I first heard recited in an address delivered by Dr. Morris Fishbein, editor of the *Journal of the American Medical Association.* They are similar to those published in the "Life Tables for the City of New York on mortality returns for the triennia 1879–1881 and 1909–1911." (See G. C. Whipple, *Vital Statistics.* New York: John Wiley and Sons, 1923.) The life expectancy of a man of 35 as given in the American Table of Mortality which is used by American insurance companies is 32 years. The discrepancy I take to be due to the fact that the latter tables are based upon selected risks. Even so, the relative difference between the life expectancy of a man in 1850 and 1925 is the same — i.e., there is only an increase of a fraction of a year.

PART II

THE HUMAN BODY AS AN ORGANISM FOR THE CONVERSION OF FOOD AND AIR INTO ENERGY AND INTO TISSUE

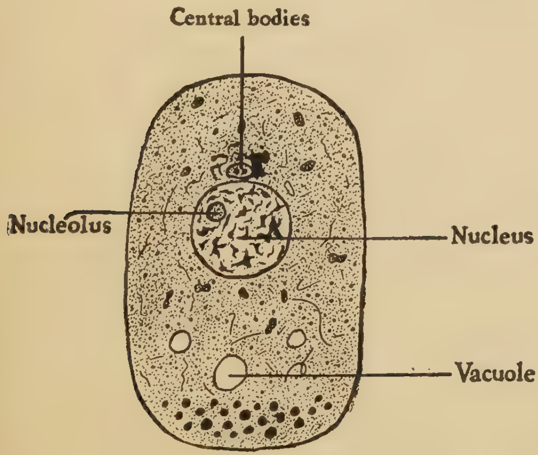
CHAPTER I

THE BASIS OF STRUCTURE, CELLS, TISSUES, AND ORGANS

Not so long ago, within the memory even of young men, there could be seen in the streets and the cafés of the pleasant little city of Louvain, which had not then acquired its sinister reputation, and was known only to antiquarians with a taste for *incunabula* and to utilitarians with a taste for plans of strategy, a grave-featured old gentleman wearing the black broadcloth coat with the velvet collar of the Second Empire. He was Theodore Schwann, professor of physiology in the University, and the discoverer of the animal cell. "To sit and talk with him about the germ theory and the progress of histology," said Professor Ray Lankester, "was like conversing with someone arisen from the dead." Well it might be: what changes had come over the world since that far day when, as a young man of twenty-nine, he was the first to make out a nucleus in the cells of animal tissue! He had been present at that lovely battle of Organic Evolution; and had watched the terrible gun-fire of Huxley's artillery rake the ranks of the bishops and other clergy, exposing great gaps in their intellectual barriers, and flinging their outworks of dignity and self-sufficiency shivering into the air. He had seen the cavalry of Haeckel and Wallace and Tyndall thunder up the slope, spike the cannon, destroy the ammunition (most of it was wet), capture the enemy's regimental colours, and what prisoners they wanted, such as Romanes, J. A. Froude, and the Vicar of Norwalk, and wait until the infantry under Cope and Weismann and Du Bois-Reymond and Williston moved over quietly and in good order and took possession of the field. He had seen, what was less exciting but really more valuable to the human race, his cells studied by Rudolph Virchow, as the basis of all disease processes, showing that these processes were essentially the same as the normal, that they followed regular and determinable laws. He had been fascinated when a Frenchman, Pasteur, demonstrated the cause of all the plagues and epidemics of mankind and animals. He lived long enough to see the beginning of those investigations into the activity of his precious cells carried on by many men, notably Wilson and McClung in this country, under whose hands the cell seemed to swell into a veritable universe, so diverse and complex were the activities of its microcosmic chromosomes and their accessories. And all the while he had sat in the cafés of the pleasant city of Louvain, sipping his bock, placidly oblivious to the effect which Professor Victor Horsley thought alcohol had upon his tissues.

The cell doctrine (which he founded along with Schleiden, who first made out cells in plants) states that all living tissues are made up of units called cells, just as all brick walls are made up of units called bricks; it is probably the most important generalization of biology. No one can understand the processes of the body in health, and even more certainly no one can understand them in disease, unless he thinks in terms of the activities of individual cells or of groups of cells. In most text-books on biology are set down at great length details of the structure of an ideal cell. It does not seem to me that this is necessary. An examination of the diagram of a cell here reproduced (Figure 7) will yield as much information as is required for anyone not technically interested. The distinction between the nucleus and the cytoplasm is obvious.

Certain generalizations about the cell are, however, important. One of these is the method of division. Usually this is accomplished by a complex process, in which the nucleus arranges itself into a long, beaded chain, then breaks up into a definite number of rods, called chromosomes, each chromosome dividing into two, so that the two new cells have an equal amount of the nuclear material of the original cell. All regeneration of tissue, all growth, all healing of wounds, depend upon this property of cells to divide and form new cells. When a female germ-cell, or egg, is fertilized by the male element in the process of reproduction, an interesting and vital variation of this process occurs. The developing egg early begins to form distinct cells, which later become the germ-cells — eggs or sperms — of the new individual. In doing so, the cells divide in a way that never occurs at any other time in the history of the body. The number of chromosomes of the new germ-cells is reduced in number to half that of the rest of the body-cells (this has been called the synapse), the number of chromosomes of the body-cells of any species being invariably constant. Thus when the male and female cells later coalesce in reproduction, each contributes to the first cell of the new individual an equal number of chromosomes, bringing that number up to the standard for the species. Thus also the new individual starts out with an inheritance which is exactly half and half from each parent.



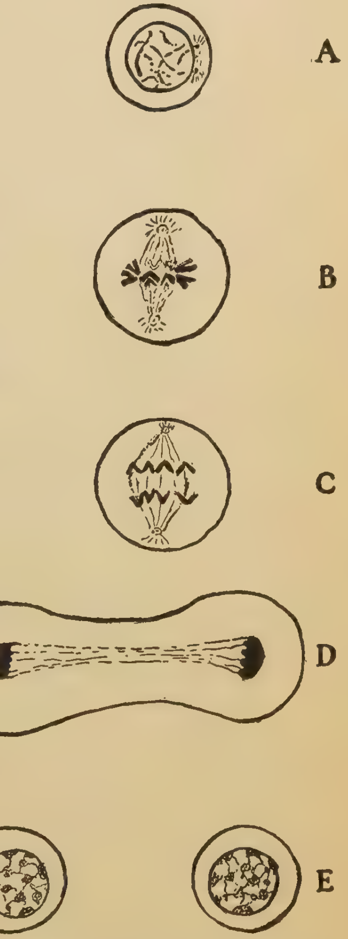


FIGURE 7

A typical cell (above).
Cell division by mitosis (at the right.)
A. Cell with nucleus, in prophase, chromosomes appearing in the nucleus and centrosomes arising.
B. Metaphase, chromosomes at equator of fully developed spindle. They are split lengthwise.
C. Anaphase. The separation of the two groups of chromosomes.
D. Telophase, massing of two groups of chromosomes and division of the cytoplasm.
E. Completion of the division of the single cell. The two new cells with the nuclei in resting phase.

Another conception of fundamental importance for an understanding of cells is that they become specialized, some more highly than others. For instance, muscle-cells have a special structure which gives them the property of contractility. This is their work in the body, and they cannot be made to do any other kind of work. They cannot, for instance, assume the functions of gland-cells, which are endowed with the property of secreting or manufacturing material, usually a juice, useful in the carrying on of the bodily activities. All cells, however, have certain general activities in common — all are able to maintain life in themselves by converting food and air into energy and into protoplasm.

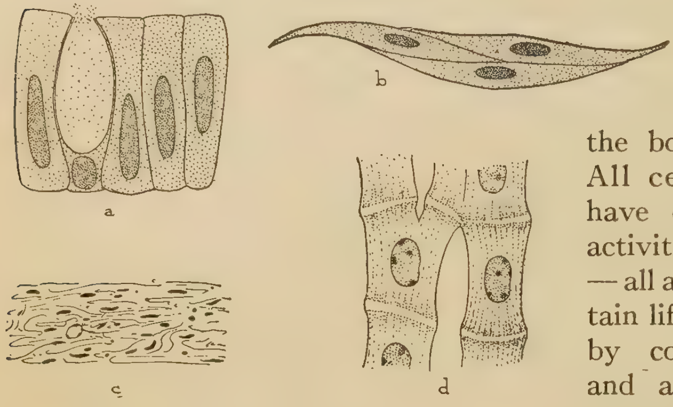


FIGURE 8

Examples of cells of the human body.
- *a. Epithelial or gland-cells. (One filled with secretion.)*
- *b. Smooth muscle-cells.*
- *c. Connective-tissue-cells.*
- *d. Heart-muscle-cells.*

When a number of cells of the same kind are found together, the structure is called a tissue. Thus we can distinguish five general kinds of tissue: (1) Epithelial tissue, represented by the skin, by the covering of the inside of the mouth, the coat of the stomach and intestines, etc. (2) Connective tissue, represented by many cell groups differing widely in appearance — by tendons, by bone, by cartilage, by "gristle" (which is sometimes cartilage, sometimes tendinous masses); the connective tissues are the binding or cementing elements in the body and are of great importance. (3) The blood, which is a true tissue, consisting of two different types of cells — the white and the red — swimming in a liquid medium, the serum. (4) Muscle-tissue, which consists of

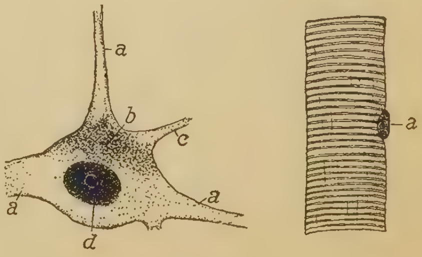


FIGURE 9

Types of body-cells. Nerve-cell and voluntary-muscle-cell. Nerve-cell: a. Dendrons. b. Pigment Granules. c. Axon. d. Nucleus. Muscle-cell: a. Nucleus. Note that the voluntary-muscle-cells are striped.

three types of cells: (*a*) the voluntary-muscle-cells, such as the muscles of the arm, which we can move at will, and which appear banded under the microscope and are hence called striated; (*b*) the involuntary-muscle-cells, such as occur in the intestines and contract without any volition on the owner's part, and which, not being banded, are called smooth or unstriated; and (*c*) the heart-muscle-cells, which resemble in appearance the voluntary, striated, or banded muscles, but which of course, like the unstriated muscles, contract without volition on the owner's part. (5) Nervous tissue, which is made up of very highly specialized cells; they consist of a cell-body from which goes out almost always a long tendril to make contact either (*a*) with a muscle, for it is by nervous impulses that muscles move; or (*b*) with sensory end-plates, such as the organs of feeling in the skin, the taste buds in the tongue, the organ of hearing; or (*c*) with other nerve-cells. The nerve-cells are formed in definite numbers during development, are never added to after maturity, which in this case means about the age of three, and do not regenerate if destroyed by disease (such as infantile paralysis) or injury: the nerve tendril, or strand, conducting impulses can, however, regenerate, provided the cell from which it springs is intact.

In every part of the body these tissues are found together, in such varying numbers as will conduce to the smooth performance of the particular function involved. Nowhere, for any importantly measurable space, do we find any tissue single and alone. When a group of tissues is massed together in one place to perform a function or a set of functions, the term "organ" has been assigned to that structure — the liver is an organ; so is the eye, the kidney, the foot, the skin, the cerebellum. When a group of organs perform a unified series of functions, we call it a system — the digestive system, the muscular system, the nervous system, etc. It is these systems which we now propose to study, analysing them in order to obtain an idea of their structure, or anatomy (which may be recognized as gross anatomy, that which can be seen with the naked eye; as histology, the finer or microscopic structure; and as embryology, or the method of development, which throws much light on the technical problems of the anatomist by explaining the reasons for certain structural arrangements, but which we shall not need to dwell upon to any extent in this book); to obtain an idea of their workings, or physiology (which may be merely mechanical, as in the movements of the heart or bladder, or chemical, as in the action of the secretions from glands like the digestive glands, or physico-chemical, depending upon the pressure of chemical solutions, as in the excretion of urine in the kidneys or the absorption of oxygen by the red blood-corpuscles, or what we can call vital, which means that we have as yet no insight into their operation, as illustrated by the impulses along nervous tissues); and to obtain an idea of their changed appearance in disease and the perverted functions which result therefrom.

It is important to remember, however, that, while we analyse them for purposes of study, their functions are interdependent, the whole body going forward as a unit.

CHAPTER II

THE FRAMEWORK OF THE BODY, THE BONES, THE JOINTS, AND THE MUSCLES

It is the bony skeleton which gives the body its general shape. The bones are held together by ligaments of connective tissue, allowing movement between the bones; and these points of juncture, which are much more intricate than they appear to be, are called joints. The movements of the joints are made possible by the contraction of muscles. Muscles are attached from one bone to another, the spots of attachment being known technically as the point of origin and the point of insertion. Sometimes, as in the case of the eye, the point of origin of a muscle may be on a bone and the point of insertion a soft tissue.

In the drawing (Figures 11 and 12) the artist has made a good representation of the bony skeleton, and I have had the name of each bone set down beside it. I have no intention in this small book of describing every bone in detail — all of its bumps or tuberosities and all of its furrows or fossæ. If anyone cares to undertake this regular intellectual exercise of the first-year medical student, he will find the facts in any anatomy such as Gray's, Piersol's, or Cunningham's, set down in great detail, or in an anatomy designed for nurses in training (such as Little's) in less but sufficient detail. It always seems to give medical students great pleasure to find that the bone they have in their upper arm is called the humerus, and that it has a great and a small tuberosity and a bicipital groove, that it fits into a cavity in the scapula called the glenoid fossa; the pleasure is of the same quality as that naïve delight which Molière's Babbitt enjoyed when he discovered he was talking prose. But these descriptions take up much more space than is at my command now, and are not of any importance to an understanding of the workings of the body.

We may, however, indicate a few points about the bones. In

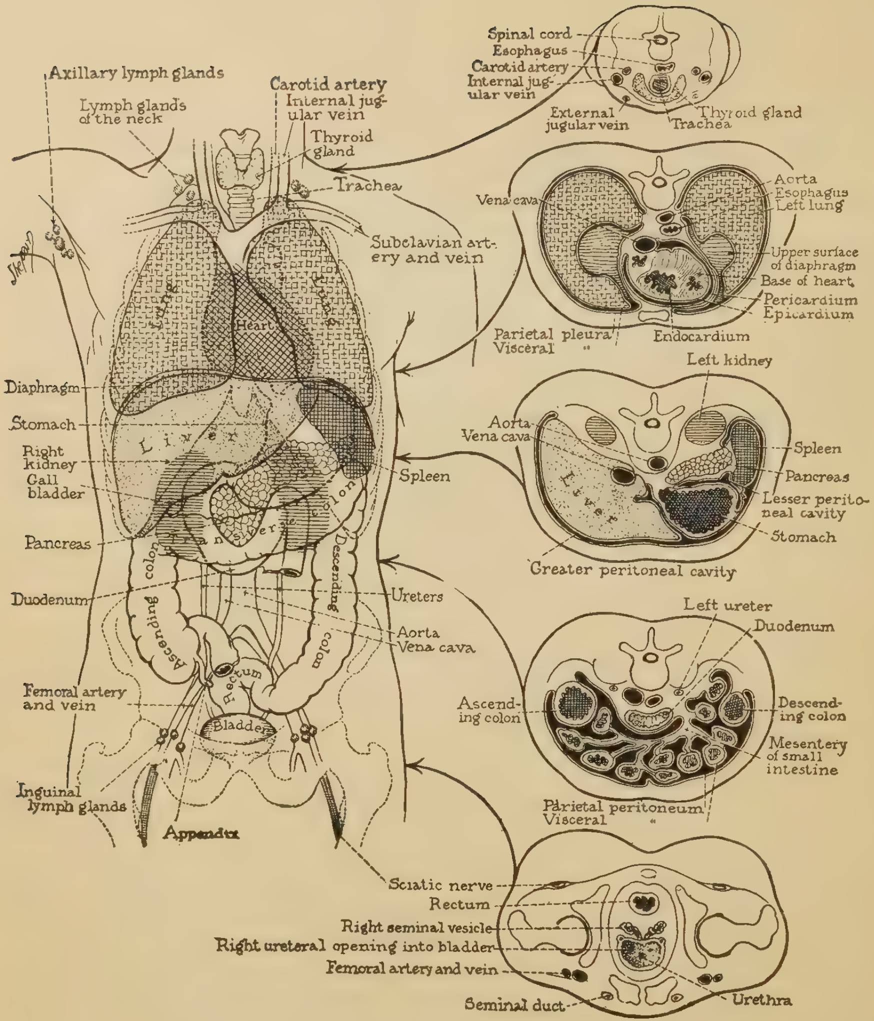

Spinal cord
Esophagus
Carotid artery
Internal jugular vein
External jugular vein
Thyroid gland
Trachea
Axillary lymph glands
Lymph glands of the neck
Carotid artery
Internal jugular vein
Thyroid gland
Trachea
Subclavian artery and vein
Vena cava
Aorta
Esophagus
Left lung
Upper surface of diaphragm
Base of heart
Pericardium
Epicardium
Parietal pleura
Visceral "
Endocardium
Heart
Diaphragm
Stomach
Liver
Right kidney
Gall bladder
Spleen
Pancreas
Transverse colon
Duodenum
Ascending colon
Descending colon
Ureters
Aorta
Vena cava
Rectum
Femoral artery and vein
Bladder
Inguinal lymph glands
Appendix
Left kidney
Aorta
Vena cava
Spleen
Pancreas
Lesser peritoneal cavity
Stomach
Liver
Greater peritoneal cavity
Left ureter
Duodenum
Ascending colon
Descending colon
Mesentery of small intestine
Parietal peritoneum
Visceral "
Sciatic nerve
Rectum
Right seminal vesicle
Right ureteral opening into bladder
Femoral artery and vein
Seminal duct
Urethra

FIGURE 10

Topographical view of the human body. This is inserted for the benefit of those who put their fingers on some part of the body and ask — "What is under there?" The drawing is somewhat complex but will repay careful study. To the right are cross-section views at five different levels, the arrows indicating the levels from which the sections were taken.

Note the two divisions of the body cavity — chest and abdomen — made by the diaphragm. Note the position and shape of the spleen: it is represented nowhere else in this book. Note the lymph nodes in the neck, under the arm, and in the groin (designated inguinal — extreme lower left side of the diagram). Note in the cross-sections how the lungs are separated from the chest wall by the pleura, just as the heart is enclosed in the pericardium, and the stomach, intestines, liver, and spleen are separated from the abdominal wall by the peritoneum. Note that the kidneys are outside the peritoneum. Look up the account of kidney stone, to see what significance this had for "the stone age of surgery."

Figure 13 a typical long bone has been represented as sawed lengthwise in order to show its structure. Note that it is throughout the greater part of its length hollow: it has the arrangement which modern mechanics has found to combine at once the greatest strength with lightness. The insides of the long bones have an organ — the marrow — which belongs to an entirely different system, the blood, for in it blood-cells are formed. Outside of the bone is a membrane, the periosteum, from which, in the early stages of bony development, the young bone-cells are formed. Some surgeons believe that a bone will not unite properly if it is broken unless the periosteum is preserved. Note that in the middle or shaft the bone is made up of very compact tissue, but that towards the ends it becomes spongy or, in technical terms, cancellous. Over the top of the bone, where it meets another bone at a joint surface, is a layer of cartilage.

The development of bone is a matter of great interest. Before birth, when the outlines of the bones are first discerned, they are all cartilaginous; as time goes on, calcium salts are formed in the cartilage by the bone-cells and ossification takes place. During infancy and youth the two ends of the bone are united to the shaft only by cartilage, the ends being called the epiphyses, the middle the diaphysis. Complete union of the epiphysis to the diaphysis and complete ossification of all bones do not take place until the twentieth to twenty-fifth years of life.

The practical importance of these things should be evident. In childhood and youth, the bones being softer, a broken bone is more likely to be what the surgeons have poetically described as a "green-stick fracture" — a splintering such as occurs in a young sapling rather than the sharp break which would occur to an old twig. Sometimes injuries occur which are simply the separation of an epiphysis. Inasmuch as ossification occurs in different bones at different ages, and as this is presided over by certain of the ductless glands, notably the thymus, and now that we have the X-ray and can determine absolutely when ossification is or is not present, the period of ossification has a considerable bearing on diagnosis in certain cases of disease of the ductless glands.

A typical joint is the juncture of two bones, these being held together by ligaments, which wrap over from one to another,

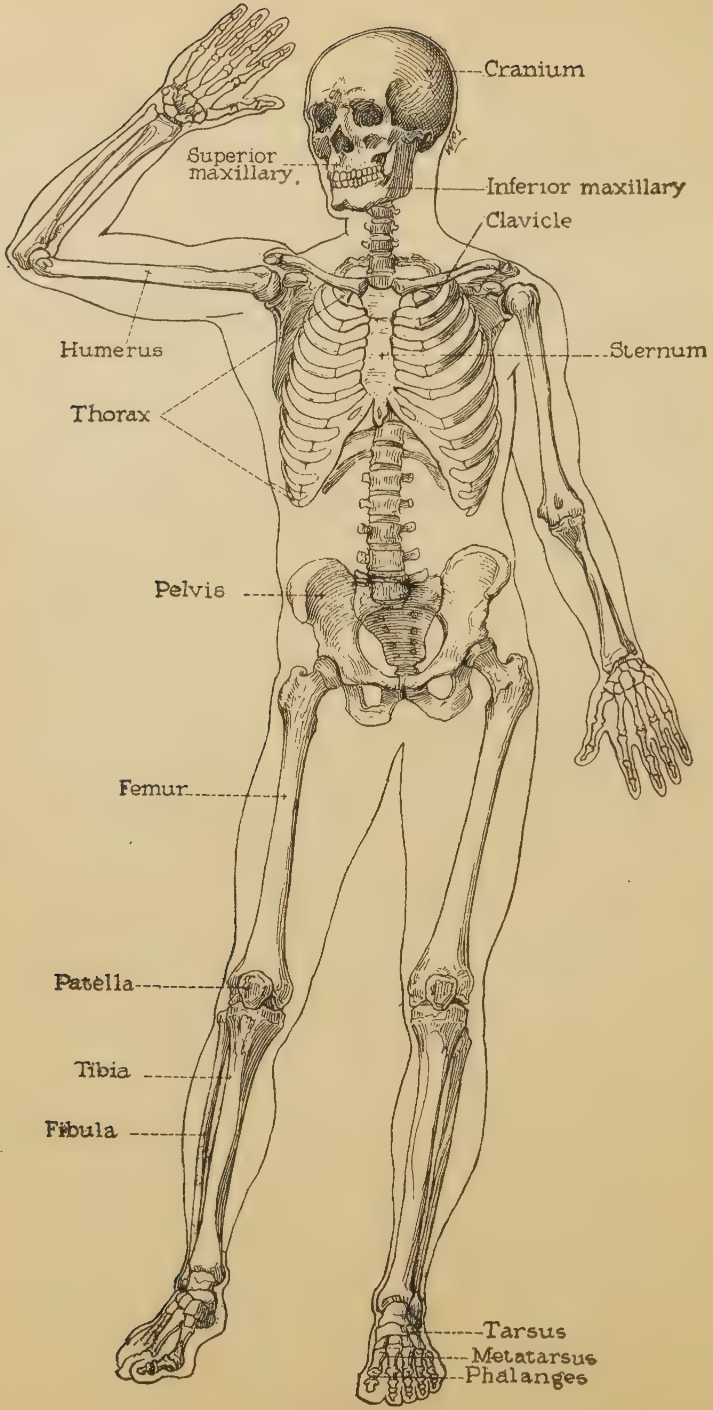

Cranium
Superior maxillary
Inferior maxillary
Clavicle
Humerus
Sternum
Thorax
Pelvis
Femur
Patella
Tibia
Fibula
Tarsus
Metatarsus
Phalanges

FIGURE 11

The bones of the human body. Front view.

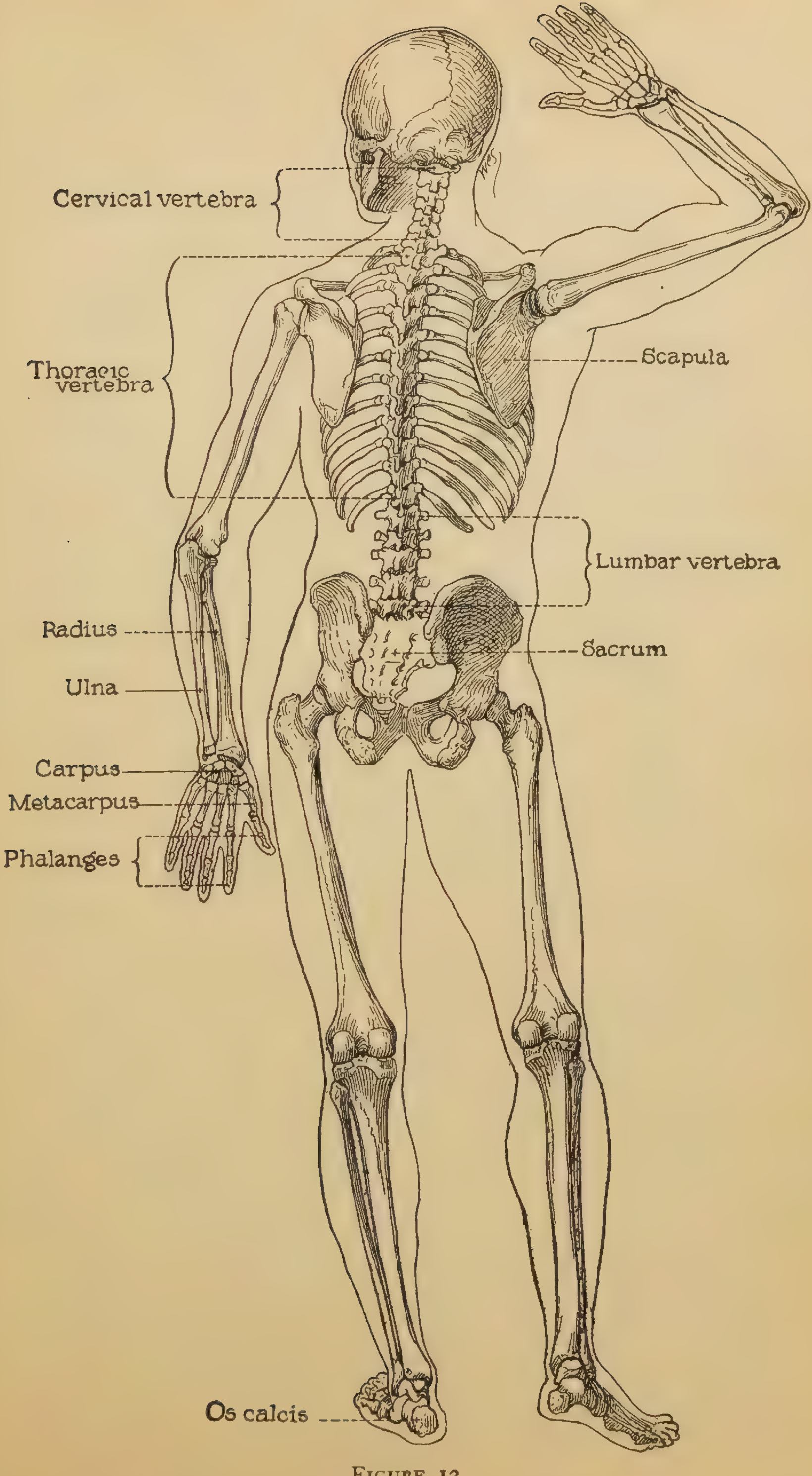

Cervical vertebra
Thoracic vertebra
Scapula
Lumbar vertebra
Radius
Sacrum
Ulna
Carpus
Metacarpus
Phalanges
Os calcis

FIGURE 12

The bones of the human body. Back view.

lashing the bones firmly together; between the ends of the bones a thin membrane covers the approximating surfaces, and between them is a thin lubricating fluid. The membrane is called the synovial membrane, the fluid the synovial fluid. The joint surface is a most delicate structure, and injury to it or infection of it is one of the most serious conditions possible, never to be treated lightly. A dirty knife stuck into a joint is just as dangerous as a dirty knife stuck into the abdomen.

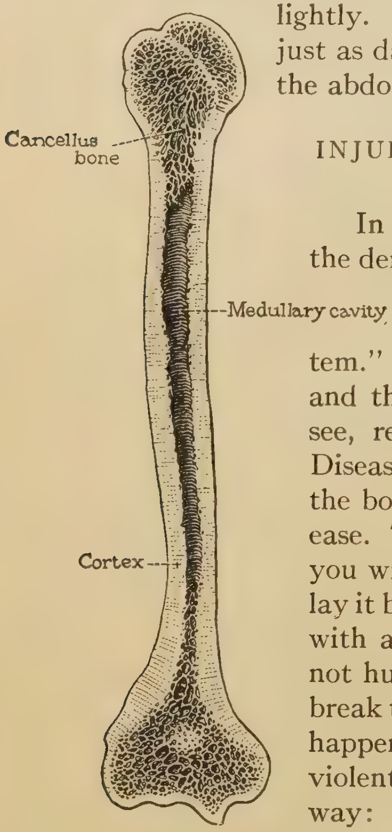


FIGURE 13

A bone cut lengthwise.

INJURIES AND DISEASES OF BONES AND JOINTS

In most of the sections of this treatise the derangements of the organs will be considered under a heading reading "Diseases of the So-and-So System." In the case of the bony framework and the joints of the body this is, as you see, replaced by the title "Injuries and Diseases," etc. The peculiar danger of the bony framework is injury and not disease. This because it is the most brittle. If you wrap a broomstick in a feather pillow, lay it between two chairs, and hit it sharply with a sledge-hammer, you will probably not hurt the pillow, but you will certainly break the broomstick. That is exactly what happens to the thigh when the body falls violently on a hard pavement in a certain way: the muscles, which represent the pillow, suffer only minor injuries, but the thigh-bone, the femur, which represents the broomstick and is brittle, is fractured.

Forty years ago, before the X-ray was discovered, the surgeon was in about the same position in placing the two ends of the bone together as you would be if you had to approximate the two ends of the broomstick through the enveloping pillow. A hundred years ago he was in an even worse predicament, because general anæsthesia was unknown, and he had to put the ends of the bone together while the patient was jerking and writhing in pain. This problem of the setting of a fractured bone is one of the oldest in medicine. Owing to these two modern miracles of applied science, the anæsthetic and the X-ray, it has become a matter merely of mechanical ingenuity.

Fractures, or the breaking of bones; dislocation, or the unapproximation of joints; and sprains, or the tearing of ligaments without either fracture of the bone or dislocation of the joint, are the common injuries to the body framework. Grief arises when a simple injury is considered to be "only a sprain" and allowed to go on without proper examination, which means examination by the X-ray. Every surgeon can recall hundreds of cases in which, following what appeared to be a trifling fall or injury, the diagnosis of sprain was made, and the patient was allowed to go about, the disability meanwhile becoming more and more severe. Finally an X-ray has revealed an actual break in the bone, or a dislocation of the joints, and properly applied surgery has saved the patient further discomfort, and given ultimate restoration of function.

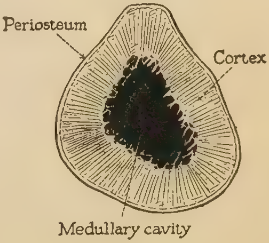


FIGURE 14
A bone cut crosswise.

For the treatment of fractures surgeons have worked out a number of devices of great ingenuity. All of them depend upon holding the broken ends or the broken fragments of the bone in place until the process of healing takes place. This act of healing is one of the most interesting as well as one of the most mysterious of all the processes of nature. When a bone is broken, and the two ends brought together, changes begin to occur in each end similar to those seen when the bone is first formed in the embryo. Connective-tissue-cells are thrown out over the gulf like strands of a rope bridge, and along them bone-forming cells later begin to lay down new bone. What initiates this process it is impossible to say; how the cells at the ends of the broken bone *know*, if you want to put it that way, that they must begin to form new cells to bridge a gap — in other terms, how they are suddenly stimulated to this active process of regeneration — is very mysterious. They go on forming bone until the break is filled in with new osseous tissue, and then always go a little further, strengthening

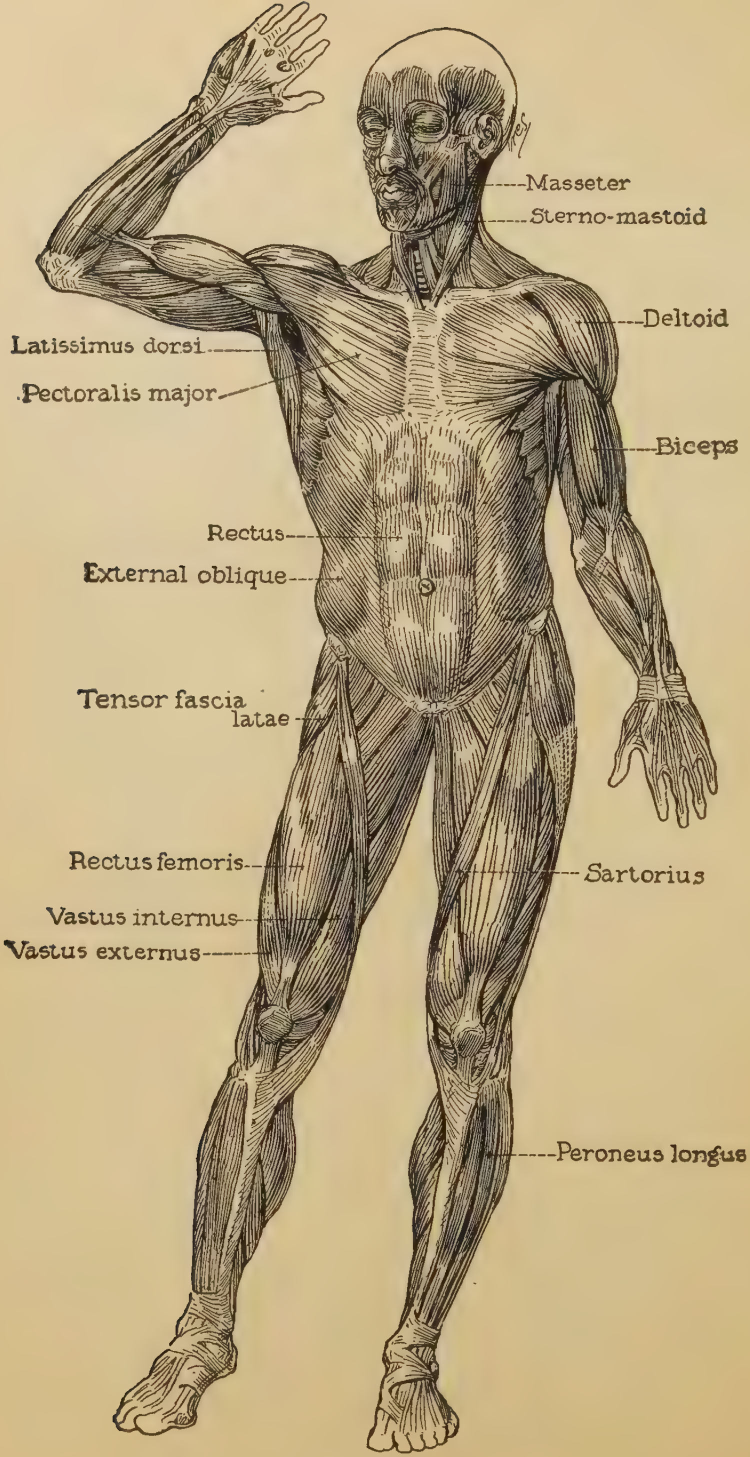

Masseter
Sterno-mastoid
Deltoid
Latissimus dorsi
Pectoralis major
Biceps
Rectus
External oblique
Tensor fascia latae
Rectus femoris
Sartorius
Vastus internus
Vastus externus
Peroneus longus

FIGURE 15

The muscles of the human body. Front view.

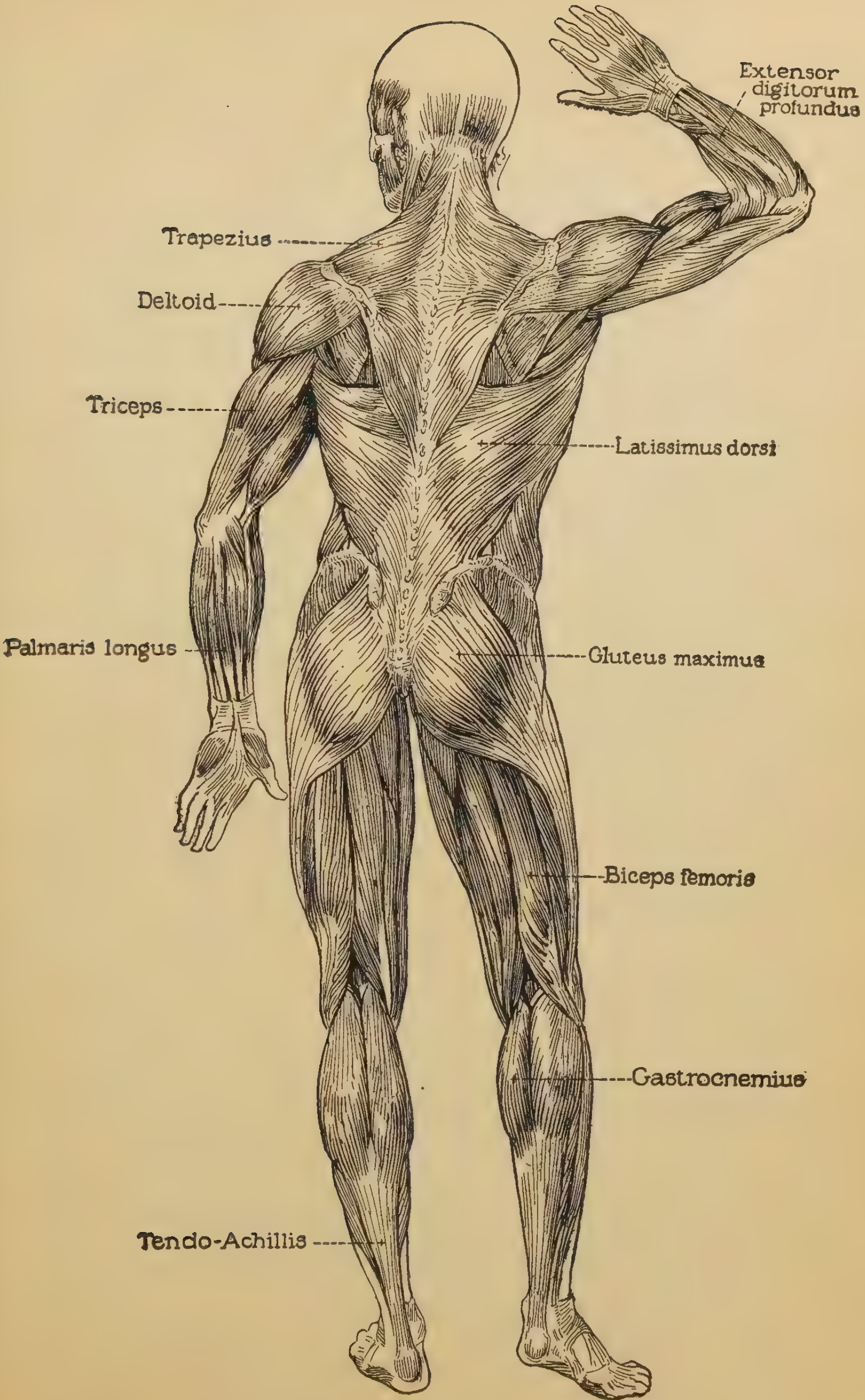

Extensor digitorum profundus
Trapezius
Deltoid
Triceps
Latissimus dorsi
Palmaris longus
Gluteus maximus
Biceps femoris
Gastrocnemius
Tendo-Achillis

FIGURE 16

The muscles of the human body. Back view.

that particular weak place with a little extra bone, so that it is easy to tell the place where a bone has been fractured by the occurrence of this extra amount of tissue, the *callus*. When the healing is complete, and the broken part is properly buttressed, the formation of new bone ceases; this is quite as mysterious as the initiation of the process, or even more so. How do the bone ends "know" that the healing is complete? Why do they stop this active process of piling up new bone? We do not know. Sometimes, indeed, the process does not stop and large masses of exuberant callus form, even enough to interfere with function. We are equally in the dark as to the cause of this.

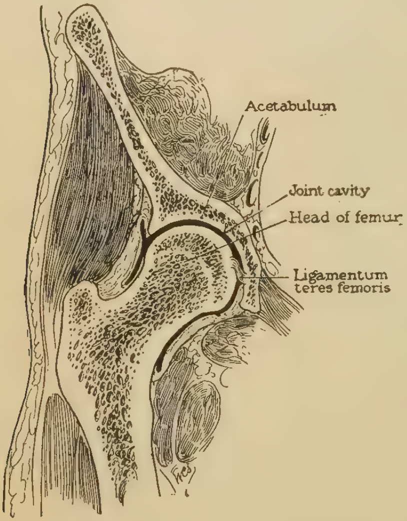


FIGURE 17

A typical joint. Cross-section of the hip joint.

The methods used to hold bones in place after fracture are splints, plaster-of-Paris casts, and the application of metal or ivory plates to the bones themselves through a surgical incision. This latter method, which was greatly in vogue a few years ago, has now largely been given up, except in special cases. The experience of surgery with splints is thousands of years old, and every possible kind of fracture in every place in the body is known and the best way of splinting it determined by the experience of thousands of cases. To illustrate this, a fracture at the elbow joint is usually fixed with the arm bent as far as it will go; this is called the Jones position, after a Liverpool surgeon who, after trying the end results with hundreds of cases of fracture of this kind, demonstrated that those put up in this position healed better and had the best final results. He showed that the muscles bring the broken fragments inevitably together when the arm is fixed in that position.

The X-ray is the most useful of all the adjuncts to trained skill in the treatment of fractures. It is possible to observe the extent and nature of the injury as soon as it occurs, watch it while reduction (the technical name for the approximation of the broken ends) is done, and to be certain afterwards that the bones are in good position. By this means the number of crippling deformities following fractures, which were common in the old days, has been reduced almost more than any men stop to realize. The X-ray and anæsthesia have in this one field minimized human suffering, and, what is more important, lameness, crippling, and disability, in a way which would have seemed in the Middle Ages nothing short of a succession of miracles.

Compound fractures are those in which an end of the broken bone tears through the tissues and breaks the skin to the surface; they are far more difficult to heal and far more dangerous than simple fractures because the element of infection is likely to be added. Non-union sometimes occurs and for various reasons; the extremely severe crushing injuries are the most frequent causes of non-union.

Dislocations, in which the bones of a joint slip out, have been quite as familiar as fractures to the practitioners of the healing art through the ages. Much the same principles apply to their treatment as to fractures — the control of proper reduction by X-ray pictures, the abolition of suffering with anæsthesia, the proper handling in the light of age-long trial and observation.

Deformities to bones and joints are second in frequency to injuries. Sometimes the deformity is due to disease — as in the case of those hunchbacks whose deformity of the spine is due to tuberculosis of the vertebræ. Sometimes the deformities are the result of injuries. Some deformities, however, are the result of neither disease nor injury. I will name three common ones — curvature of the spine, congenital dislocation of the hip, and flat-foot. I shall not have space to discuss all of them. One, however, is so frequently found, and so often spoken of in everyday talk, that it should be understood in some detail — flat-foot.

The foot is not merely the end of the leg, it is an *organ*— well designed for holding the weight of the body in such a way that there is a resilience, a springlike quality, to its support, and for propelling the body in walking, pushing it along, exercising meanwhile an elastic quality which protects the body from jars and gives ease of continuity to the progression. These properties — stability of support combined with elasticity of tone — are accomplished in the foot by the arrangement of the bones in arches, the arches being readily movable and supported by the tendons of the powerful leg-muscles. It is much as if we had in the foot two powerful steel springs, one extending lengthwise of the foot from heel to toe, the other crosswise at the base of the toes; if they were not there, walking would be like riding in an automobile without springs, which you may be assured would be an exceptionally uncomfortable process.

If you will take a piece of brown paper into your bath-room some morning, wet your bare feet daintily, and stand upon the paper for a moment, you will see an outline which will give you a good idea of these arches. If the foot is normal and has good arches, the print will show the heel and the mark of the base of the toes and their ends, and between the heel and the toe a base line will extend along the outer border of the foot. There are all degrees of flat-foot, and of weak-foot, and they may be measured roughly by how far the inside of the foot makes an impression on the brown paper.

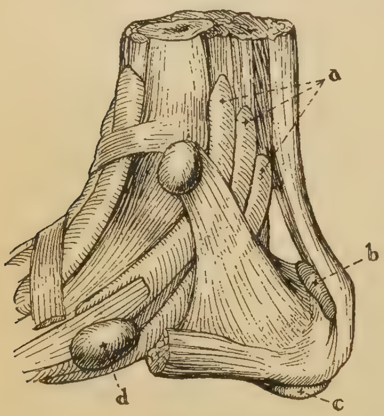


FIGURE 18

The bursæ in the heel of the foot. A bursa is a small serous sac, a sort of cushion. It may get inflamed and cause painful feet. Often when the feet are treated for flat-foot the inflammation of one of these bursæ is the cause of the pain. a. Bursæ under the tendons. b. Bursa under the tendon of Achilles. c. Bursa under the heel. d. Bursa under the middle of the foot. (*From "The American Journal of Surgery."*)

It must be evident to anyone who will really think about the problem in terms of the factors which I have mentioned (the fact that there are two arches, either or both of which may break down, the fact that the ligaments may stretch or the muscles give way) that constant use — standing — on a weak foot may flatten it, while constant use of a strong foot, held by strong muscles, will make it even stronger — that every case must, for the sake of treatment, be individualized and studied according to its own needs. Further, there are all degrees of flat-foot — when the arch begins to sag, and the muscles are tugging to keep it up, the imprint of the foot may show little change and yet the symptoms be far more distressing than later, when complete collapse has occurred and the muscles have resigned themselves. Then the imprint shows a complete pattern of the foot, the inner surface flattened out and as conspicuous as the outer. And yet in this "rigid" form the patient, while he has some crippling, walking as he does with that characteristic hobbled gait, is likely to be freer from pain than when in the earlier stage.

The treatment must depend upon the interplay of the factors involved. Insignificant as it possibly appears to the outsider, the consequences of flat-feet may be truly tragic, not only in pain, but in disability, in the cutting off of ordinary activities, exercise, etc. I recall a case of diabetes the cause of which may fairly be said to have been flat-foot — the patient for years took no exercise, got badly overweight, and this predisposed to diabetes. The use of arches or plates, so nonchalantly recommended by shoe-salesmen and other scholars, is occasionally justifiable, but usually they support too much and hence eventually weaken the muscles whose business it is to support the arch. Exercises to strengthen the muscles of the calf and foreleg, very carefully designed shoes, which throw the weight-bearing lines of the foot in a different direction, and in certain cases mobilization of the foot by operation are the resources which the orthopædic surgeon has at his command.

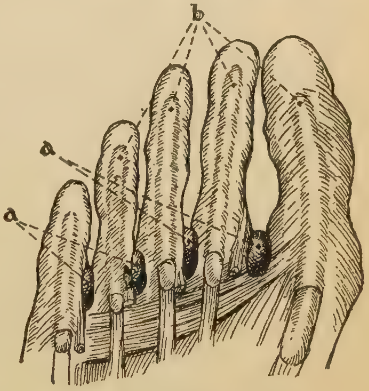


FIGURE 19

The bursæ between the bones of the toes (a, a,). (*From "The American Journal of Surgery*.") *See description under Figure 18.*

Flat-foot is not, however, the usual cause of painful feet. The pain is due to the inflammation of a series of bursæ located on the bottom of the feet, one under the heel, several just between the roots of the toes. Removal of these bursæ by a simple operation results in the cure of many "flat-feet." (See Figures 18 and 19.)

DISEASES OF THE BONES AND JOINTS occur, though less frequently than either their injuries or their deformities. The most frequent are: (1) tuberculosis, which affects both the bones and the joints, the commonest sites being the spine, the hip, the knee, the ankle, and the wrist; (2) pus infection in the bone, called osteomyelitis, in which the marrow and the bony structure both are involved, and which results in considerable destruction unless the pus is drained; (3) syphilis of the bone, particularly affecting the tibia, or main bone of the foreleg, and the septum of the nose; (4) tumours, often malignant and usually multiple.

"Rheumatism" deserves a special word. The term is used loosely to denote any pain in the bodily framework, especially around a joint; it includes some twenty or thirty separate diseases, ranging from rheumatic fever (an acute infectious disease affecting one joint after another, which swells, gets red and painful, but subsides without the formation of pus) to the chronic progressive, deforming arthritis, about which we know very little save that it continues remorselessly until nearly all the joints are chalky, twisted, and rigid. The most hopeful cases are those due to inflammation around a joint which arises from a focus of infection such as the root of a tooth or a tonsil, the bacteria in the primary site of infection having entered the blood-stream and lighted on the joint surface or its surrounding structures. Removal of the focus will result in a subsidence, which may be slow or sometimes magically rapid, in the inflammation at the joint. Septic sore throat or tonsillitis can cause a more extensive inflammation in a joint with swelling due to serous fluid in a bursa or synovial sac around or even in the joint.

The muscles are singularly free from disease processes. The only common disease of muscle is trichiniasis, caused by the entrance into the body of a parasitic worm, the trichina. In the adult state the trichina lives in the intestine, developing there from embryos lodged in the muscles of hogs, and eaten as pork or ham. When the adult worm produces the embryos in the intestinal wall, they burrow their way into the blood-stream, or lymphatics, and when they reach the muscles to which they have an affinity, they encyst themselves. In this country, owing to the care exercised in packing-house inspection, the disease occurs mostly in sporadic epidemics, but in North Germany, where raw ham and *Wurst* are freely eaten, large numbers of cases have occurred. Thorough cooking of meat will kill all the larvæ and prevent the disease.

Under the heading of muscles may be a practicable place to speak of hernia or rupture, the protrusion of the abdominal contents through the muscles, or rather between the muscles, of the abdominal walls. There are many varieties — an ingenious acquaintance of mine has written a monograph describing about fifteen. The three commonest occur at the three weakest spots in the abdominal wall — the inguinal, the femoral, and the umbilical.

A description of the inguinal form will serve as the type of all. On the front of the body on both sides a strongly marked line represents the point at which the abdominal muscles stop and the leg-muscles begin — both are reflected from and connected to a heavy cord of connective tissue known as Poupart's ligament. Naturally this point of jointure would be a weak place in the wall; it is made more so by the fact that in the male the spermatic cord going from the testicle outside the abdomen to the seminal vesicles inside the abdomen at the root of the bladder, and in the female one of the suspensory ligaments of the uterus, run along the canal formed by the line of juncture. Thus there is inside the abdomen at this point a potential opening. At times a loop of the intestines or omentum may get caught at this point and begin to push itself along the line of cleavage between the muscles. Anything which increases intra-abdominal pressure, such as coughing, straining in the act of defecation, etc., facilitates the process. Sometimes a large loop of intestine gets in the hole and cannot get back; it becomes pinched, and the blood-supply is shut off — so-called strangulation — the commonest form of intestinal obstruction. This complication of strangulation is the real danger of any hernia.

Fortunately, owing to the development of aseptic surgery, to the introduction of anæsthesia, both general and local, and to the increasing attraction of handsome and vivacious young women into the profession of nursing the cure of rupture nowadays may be ranked among the lighter forms of amusement. I know of few things better calculated to renew a middle-aged man's healthy interest in life than a well-planned herniotomy. The only alternative to operation is the wearing of a truss, one of those hideous contrivances that hang in druggists' windows on occasion, and which used to be so mysterious to me when I was a boy. I thought that they were associated with some dark and disgraceful disorder, but I have since learned to my delight that, on the contrary, even ministers of the gospel wear them. The injection of paraffin into the canal is still practised by certain ingenious gentlemen, for the cure of hernia; and as it congeals into lumps under the skin it will endow the patient with a rather bizarre contour in the intimacy of the bedchamber, but it will do the hernia no benefit.

THE SKIN

We may close this rather miscellaneous chapter by a brief reference to the covering of the entire body. There used to be an old catch question which quiz-masters in anatomy asked: "What is the largest organ of the body?" — the answer being: "The skin." Not only that, but it is one of the most interesting and mystic of structures. It is that outer rampart which separates us from the rest of the universe, the sack which contains that juice or essence which is me, or which is you, a moat defensive against insects, poisons, germs, and surgeons, through which they must break before they can storm the citadel.

A great dermatologist has called it "the mirror of the system." How its texture and colour change with changes in bodily health — now white with the pallor of fatigue or sepsis, now blue with the cyanosis of heart-failure, now greyish-yellow with what physicians call the cachexia of degenerative disease! It reacts to heat, by pouring out perspiration, which cools on evaporation; to bitter cold, to the light of the sun, to the blowing of the winds. The very storms of the soul are recorded upon it — the deep flush of anger or humiliation, the pale tenseness of fear or excitement, the sparkling iridescence of triumph or of ecstasy. The end organs of feeling, attaching it by a million fine nerve-filaments to the brain, are largely responsible for our feeling of personality, of entity.

Some strange things about it have been pointed out recently, notably by Müller — that it has intimate connexions with the vegetative nervous system, which controls or adjusts all the functions of the internal organs, so that drugs injected into the skin itself have an entirely different effect to what they have if injected under the skin or into the blood-stream. Thus sun-baths — continuous exposure of the skin to the sun as practised in the Alps by Rollier — have a positively beneficial effect upon the

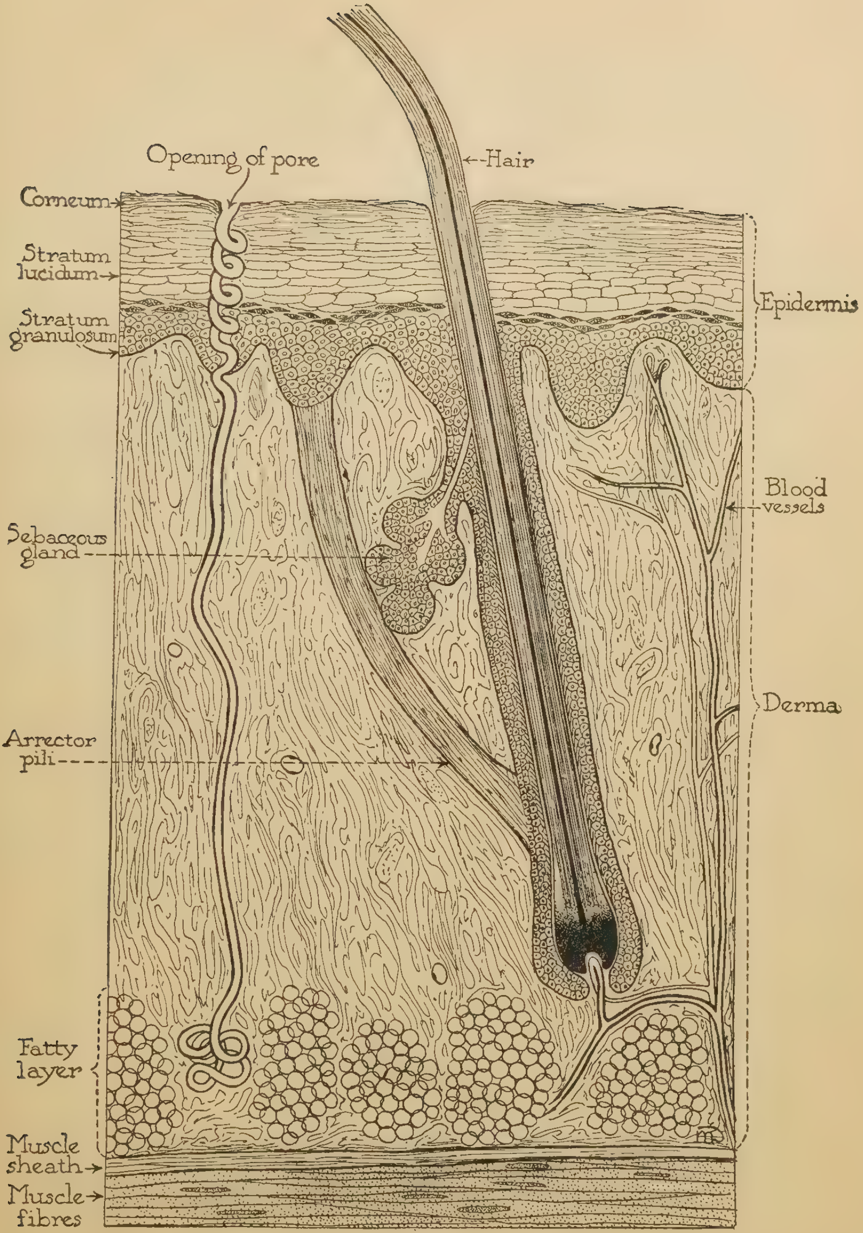

Opening of pore
Hair
Corneum
Stratum lucidum
Stratum granulosum
Epidermis
Blood vessels
Sebaceous gland
Derma
Arrector pili
Fatty layer
Muscle sheath
Muscle fibres

FIGURE 20

Diagram of a section of the skin as seen under the microscope.

whole system, flooding the deep organs with health and curing tuberculosis of the bones and joints and glands without splints or mobilization or drainage. The curative powers of water are largely dependent upon the way in which the reactions of the skin can affect deeper structures.

The skin is subject to many diseases. The special students of the subject have classified I know not how many hundred. Some of them are expressions of a generalized disease of the entire body — such as measles, scarlet fever, smallpox, and syphilis. Some are due to the invasion of the skin by animal parasites such as the itch-mite. Some are expressions of a peculiar hypersensitiveness of the blood, such as hives or urticaria. Some are infections of the skin by bacteria, such as erysipelas and acne (pimples). Some, such as the boils of diabetes, are infections dependent upon a general condition, in this case the sugar in the blood furnishing a favourable culture medium for pus organisms. Some are caused by irritation of a nerve or hæmorrhage into a nerve-ganglion, such as shingles and the familiar fever blister. Some are peculiar to the skin itself and appear not to affect any internal organ besides, such as psoriasis and eczema and seborrhœic dermatitis. The popular wisdom embalmed in the idea that if there is a skin eruption it denotes some impurity of the blood is thus seen to be shallow and inadequate.

Chapter III

THE DIGESTIVE SYSTEM

Inquisitive, mechanically minded monkeys that we are, the engine under the hood of an automobile is the greatest source of fascination to us. We must lift the hood and watch the machinery go round, and try to understand it. Finally we get to the point where we think the engine is the most important part of the automobile. Of course it is not. The wheels and axles are the essential parts. But always secondary though it is, the engine is the most interesting.

The framework, the bones and the muscles, are the essential parts of the body. To them all the viscera in the head, chest, and abdomen are mere servants. But like all great and important things the bones and muscles are simple and easy to understand. Our awe and our curiosity are expended upon the viscera, and so most of this book, because it is written for inquisitive little monkeys, must be spent upon them.

Let us take a bird's-eye view of the whole process. In the opening definition we agreed that the body was an organism for the purpose of converting food and air into energy and into tissue. The first step in the process is to reduce the food to such a state that it can be absorbed and carried to the tissues. This is the process of digestion. Simultaneously air must enter the body. This is the process of respiration. When the changed food and air have entered the body, there must be some medium in which they can be dissolved. This medium is the blood. The blood must be carried to all parts of the body. This is the function of the heart and blood-vessels, the process being called circulation. When these substances reach the various tissues, they must be converted into energy. This process is called nutrition or metabolism. In the process of conversion certain waste products will be formed; they must be cast off, as the body has no use for them. This process is called excretion. Finally some direction to the

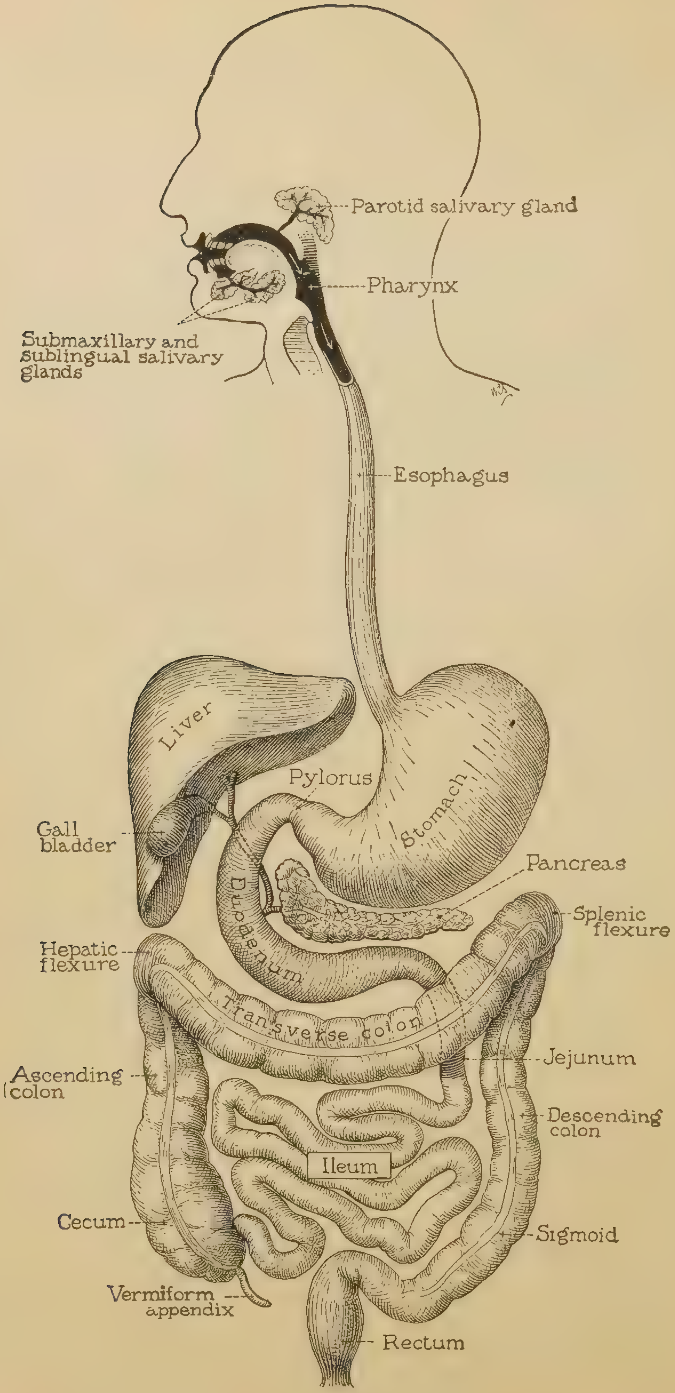

Parotid salivary gland
Pharynx
Submaxillary and sublingual salivary glands
Esophagus
Liver
Pylorus
Stomach
Gall bladder
Pancreas
Duodenum
Splenic flexure
Hepatic flexure
Transverse colon
Jejunum
Ascending colon
Descending colon
Ileum
Cecum
Sigmoid
Vermiform appendix
Rectum

FIGURE 21

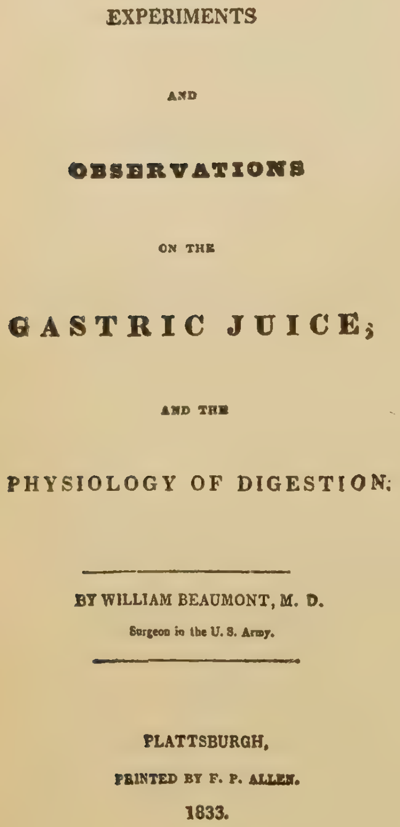
The digestive system.

whole complicated performance must be maintained. And this is accomplished by the central nervous system and by the vegetative or automatic nervous system, which seems to be co-ordinated largely by the ductless glands. These various systems and functions and their derangements we shall now briefly review.

Though the whole procedure is an endless wheel, it may be convenient to start with digestion.

After the revival of learning men began to become interested in certain apparently spontaneous changes which occurred in substances left alone in nature. For instance, why does meat get corrupted? Why do maggots swarm in it? Why does milk sour? Why does grape-juice turn into wine? Why does apple-juice turn into vinegar? Finally, why does food undergo a change in the stomach? All of these changes seemed to them to be of the same nature. They were all thought to be due to "spontaneous generation." Meat changed, maggots swarmed, milk soured, food digested — by the act of spontaneous generation or spontaneous metamorphosis.

An Italian, Francesco Redi, undertook to answer the question about the maggots. The learning of the time was certain that they developed spontaneously in the meat. He put pieces of meat into open jars, and other pieces of meat into jars over which he placed parchment and wire-gauze. The maggots developed in the meat in the open jars; they did not develop in the meat in the covered jars, but maggots grew on top of the wire-gauze or on the parchment covering the jars. The idea of spontaneous generation began to fade. What did it mean anyway? A Frenchman, Réaumur, had a pet kite. He got some of the juice from its stomach and showed that this juice dissolved food in a glass. Another Italian, an abbé — Lazaro Spallanzani — said that Réaumur was right not only about birds, but also about human stomach-juice: it seemed to melt food away. The significance of this, to the learning of the time, was that the stomach juices would convert or digest food even when they were outside the stomach: the supposed "vital" influence of the stomach was unnecessary. The abbé also found that saliva would change certain (starchy) foods even in a bottle. This was in 1782. Ensued argument. Hunter, the Great Cham of medicine in England, bellowed: "Some Physiologists will have it that the stomach is a Mill; others that it is a fermenting Vat; others again that it is a Stew Pan; but in my view of the matter it is neither a Mill, a fermenting Vat, nor a Stew Pan — but a Stomach, gentlemen, a Stomach." As no one knew what he meant, he acquired a great reputation.



EXPERIMENTS

AND

OBSERVATIONS

ON THE

GASTRIC JUICE;

AND THE

PHYSIOLOGY OF DIGESTION:

BY WILLIAM BEAUMONT, M. D.
Surgeon in the U. S. Army.

PLATTSBURGH,
PRINTED BY F. P. ALLEN.
1833.

FIGURE 22

Title page of the first scientific description of the physiology of digestion.

Matters were not much clarified after all, for fifty years later, in 1825, a New York intellectual by the name of Nathan R. Smith could say, and be applauded, that "the properties of the gastric juice suggested to the older anatomists the idea that a myriad of small worms attacked the food which was swallowed and reduced it to a uniform pulpy mass," and he believed that they were as near the truth as those "who consider the process to be performed by a chemical agent."

Fortunately about this time an Indian got shot. On June 6, 1822, to be exact, at Mackinac. His name, which will be floating on the surface of the river of time when every poet and columnist now living shall long have been forgotten, was Alexis St. Martin. The accidental discharge of a shot-gun in the trader's store of that frontier post tore off the skin and muscles in the upper part of St. Martin's abdomen and the outer layer of the wall of his stomach. A young United States Army surgeon, William Beaumont, was called to attend him. Beaumont stitched the edges of the stomach to the skin. To his surprise the patient lived. He now had a man with a hole in his stomach. Beaumont could see the stomach move. He could see the digestive juice ooze out upon the surface of the stomach. He decided to do some experiments. He attached a piece of meat to a string and inserted it into the stomach. Half an hour later he pulled out the string, to find the meat frayed at the edges. An hour later it was half gone. Two hours later he pulled out the string, but the meat was completely dissolved. He found that gastric juice appeared only when food entered the stomach or when food was being chewed in the mouth. He put a rubber tube in the stomach and drew off some pure gastric juice; he sent it to Professor Dunglison at the University of Virginia, who found that it contained hydrochloric acid. It was the first time pure gastric juice had ever been submitted to careful chemical analysis.

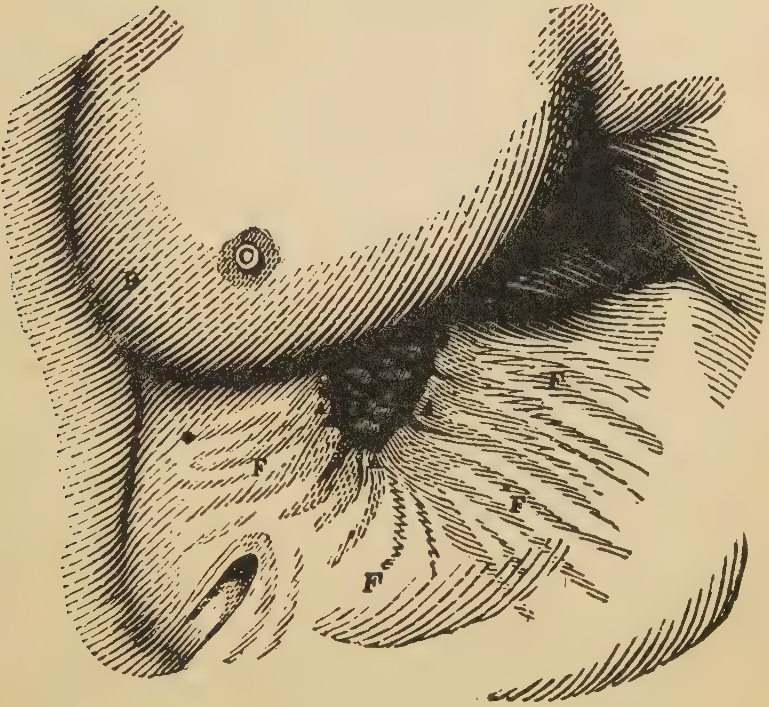
Beaumont decided that St. Martin was a valuable find. He took him into his household as a servant so he could study his stomach. St. Martin did not prove a very docile experimental animal. He got drunk. Right in the middle of a series of experiments he would disappear, sometimes for months. In spite of these temperamental interruptions Beaumont persisted. In 1833 he published his observations. The little book, published at the author's expense at Plattsburg, New York, is one of the great landmarks in the history of physiology. So carefully did Beaumont do his work — and remember it was done not in a handsomely equipped physiological laboratory, but in a frontier fur-trading post under the rudest surroundings — that comparatively little has been added to our knowledge of the physiology of digestion since his time.

The after history of the two men so strangely associated has an interest of a personal nature. In 1839 Beaumont resigned from the army and began to practise medicine in St. Louis, and in 1852 he died there. But his experimental animal lived on. He still got drunk with unphysiologic regularity, he still was known as "the man with a lid on his stomach," but still he lived on. He did not die until 1880. The young professor of physiology in Montreal at the time, named William Osler, heard of his death and offered the widow quite a sum of money for Alexis's stomach. But the widow refused and buried her husband eight feet below the surface of the earth, where young professors of physiology could not break in. William Osler went to Philadelphia. The Army Medical Museum contains no jar with the stomach of Alexis St. Martin in it. But his stomach and William Beaumont's mind taught the world nearly all it knows about digestion.

The digestive system may be conceived in its simplest form as a muscular tube into which glands all along its course pour secretions. Some of these glands are embedded in the wall of the tube; some, such as the pancreas and the liver, are so large that they lie outside and discharge their secretion through a duct which empties into the digestive canal. The muscular action of the walls of the canal pushes the food ever onward. It must always be remembered that, though for purposes of analysis we shall study them separately, these dual functions of movement by the muscular walls of the digestive canal and of chemical action by the digestive juices go on simultaneously and are interdependent. The churning of the stomach and intestines mixes the food and breaks it up so that the juices can get to every part of it, then the onward movement carries the residue and waste away so that they can be evacuated.

The movements in the mouth consist of the grasping or prehensile movements of the lips, the grinding action of the teeth, and the rolling of the bolus of food by the tongue and cheeks so that it is intermixed with the salivary secretion which is being poured out. These movements and the act of swallowing are voluntary; after they are completed, the movements of the food are beyond the control of the will.

The stomach is a bag the walls of which are largely made up of involuntary or smooth muscle-fibres. It is marked off from the intestines by a strong circular muscular band, the pylorus. During digestion in the stomach the pylorus remains closed, except at intervals when it opens momentarily to allow the ejection of a well-digested bolus of food into the intestine. The movements of the stomach, technically called peristalsis, consist first of a series of waves of contraction running from the upper end towards the pylorus. There is another stomach movement, a turning or churning, a rolling from side to side like an electric washer. Both these movements, the contraction wave and the rolling, are seen daily by the physician with the X-ray. They are controlled by the automatic or vegetative nervous system, which sends two sets



This engraving represents the ordinary appearance of the left breast and side, the aperture filled with the valve; the subject in an erect position.

A A A The circumference and edge of the aperture, within which is seen the valve.

B The attachment of the valvular portion of the stomach to the superior part of the aperture.

C The nipple.

D The anterior portion of the breast.

E The scar where the opening was made with the scalpel, and the cartilages taken out.

F F F F Cicatrice of the original wound, around the aperture.

D

Figure 23

Alexis St. Martin's Wound. (From Beaumont's book.)

of fibres to the stomach — one set accelerating the movements and one set inhibiting them. These nerve-fibres are co-ordinated in one of the large ganglia of the vegetative nervous system — the solar plexus — which, owing to the discomfiture of one Mr. Sharkey, as I remember it, was the first anatomical term I ever learned.

The stomach empties itself in about four hours. The food, in various states of digestion, is then carried forward by the intestinal peristalsis, which is much like the constrictive movement of the stomach. It is carried forward at a rate allowing time for the intermixture of intestinal, pancreatic, and liver juices, for the conversion of food into assimilable form, and for absorption, through the intestinal walls, into the blood. Finally, through the ileo-cæcal valve, it reaches the large intestine, where absorption, except for water, largely ceases and the waste products are agglutinated with the mucous, bacteria, and epithelial debris from the entire intestinal tract in the form of fæces, a stool or mould of which is evacuated from the body by the act of defecation once, according to the immutable standard of modern civilization, in every twenty-four hours.

The essential process of digestion is a chemical change, a conversion of the complex foodstuffs into a form which can be absorbed into the blood and utilized by the body. The digestive juices which accomplish this change are many in number, each one fitted for the conversion of a particular sort of food — the lipase of the pancreas for fat, saliva for starches, gastric juice for proteins. They are all of the general chemical nature of enzymes. An enzyme is a catalyzer and exerts its properties not by uniting with a given substance to form a new substance, but by exerting an influence. It is a kind of exhorter, leading chemical compounds to turn themselves into something different, if not better. For instance, oxygen and hydrogen brought together will effect no union, but if brought together in the presence of spongy platinum they form water. The platinum does not change at all: it is a catalyzer.

The action of most of these enzymes is astonishingly rapid. You may test this on yourself by chewing a piece of cracker or bread. The saliva, through its digestive enzyme, ptyalin, is amylolytic; that is, it digests starch exclusively. It does so by breaking down the complex starches into simple sugars. So, almost five seconds after the bread has been in your mouth, it begins to turn sweet. That rapidly does an enzyme work. The highly complex starch of the bread has been converted into maltose.

The digestive enzyme of the stomach is pepsin. It splits only proteins or albuminous foods: meats, eggs, etc. It is secreted by small glands all over the wall of the stomach. It acts only in an acid medium, so that the stomach glands also secrete hydrochloric acid.

After the food leaves the stomach, it is acted on by several digestive enzymes. Some of these are secreted by glands located, like the stomach glands, in the wall of the intestine. But the most powerful digestive juices of all are those secreted by the pancreas and poured into the intestine in its upper part. One of the pancreatic enzymes, trypsin, is a rapid and powerful splitter of the protein foods. Another, lipase, splits fats into simpler absorbable compounds. The third, amylase, resembles the salivary secretion, ptyalin, in that it breaks down complex starches and sugars into simpler chemical forms. The pancreatic secretion mixes with the food, as has been said, at the upper part of the small intestine. There is a long stretch of the small intestine, over twenty feet, through which the food passes after this admixture, becoming more fully digested.

What causes the digestive juices to be poured out? It is a very interesting and pertinent question. We know that they are not flowing all the time. We know this by observation about the saliva for instance. At times the mouth is dry — when food is taken into the mouth, the saliva begins to flow. This is also true of the stomach and intestinal juices. They appear in the presence of food. Why? Pawlow, a Russian physiologist, supplied a very interesting part of the answer. He showed that the digestive juices flow at the sight and especially at the smell of food. The more appetizing the food, the larger the amount of secretion. We say the mouth "waters" at the sight or smell of something we like to eat; this is literally true: the mouth does water, and so does the stomach. Carlson confirmed Pawlow's experiments, which were done on animals, in man. He obtained a man whose œsophagus had been burned and who had to have an opening made in his stomach by a surgeon. Carlson could thus measure the amount of gastric juice secreted under different circumstances. When the man smelled something he liked to eat, the gastric juice was poured out in large quantities; when something disgusting or unappetizing was seen or smelled, the stomach wall became dry. Chewing food of pleasant taste also stimulated the flow of stomach juices.

These observations have a decided practical import. Other things being equal, you will digest more of a portion of food which you like than of food you do not like. You will digest more of food with an appetizing smell — more digestive juices will be poured out. The art of the cook enters here. Also, for a convalescent or invalid, the food that is craved will be more completely digested than that which is disliked, no matter how "nourishing" the latter is.

ABSORPTION: After the food is properly prepared, it is absorbed into the lymph-vessels and blood-vessels surrounding the wall of the small intestine. With the absorption of these end products into the tissue juices the function of digestion ceases.

The chemical changes which occur in the three main foodstuffs — carbohydrates, proteins, and fats — during digestion are well known, but their recital is somewhat too complex for a work of this scope. Suffice it to say that the process is a continuous simplification, breaking them into more and more elemental chemical structures. When they reach the final stage, they are absorbed. The proteins and the starches are absorbed through the walls of the intestine into the network of small veins which ramify over its surface. They empty into larger and larger veins and are carried at last in the portal vein to the liver. The liver is a large and extremely important organ whose work is somewhat intermediate between digestion and nutrition. We shall consider briefly what we know of its physiology below. Besides the blood-vessels there are, however, other absorbent vessels on the surface of the small intestine. They are white, fine threads, which are sometimes called lacteals because they are always concerned in the absorption of milk and because their contents, the lymph, has a milky appearance. They absorb largely fats; sometimes the excess of protein. They do not empty into the liver, but merge together into larger and larger lymph trunks until the thoracic duct is formed, which runs upward along the spine and empties its contents into the blood-stream, joining one of the large veins at the root of the neck.

The bacterial content of the intestines is a matter of considerable practical importance. In the infant at birth the entire gastro-intestinal canal is sterile, but remains so for only a few hours, when a number of bacteria appear in the fæces, probably having gained access to the intestines by way of the mouth. However, none of these are of the type which later make a permanent home in the intestines. About the third or fourth day of life, when the mother's milk has been established and is being ingested in good quantity, an entirely different flora appears, mostly of the family called *Bacillus bifidus*, an acid-forming organism. This persists during the nursing period. With the beginning of the use of a general diet the character of the bacteria in the intestines again changes, and remains fairly constant during the rest of the individual's life, varying somewhat with the character of the food eaten, and, of course, being changed sometimes by the implantation of positively pathogenic organisms, such as the dysentery bacillus, and the diplococcus recently identified with the production of chronic ulcerative colitis.

The stomach is nearly always free from bacteria, the highly acid nature of its contents destroying most of them. In the intestine the number of bacteria increases progressively as we go downward, the large intestine swarming with them. The stool is normally by bulk about one third bacteria. In general there are three or four main types, the *Bacillus coli communis*, as its name implies, being the most frequent and regular inhabitant of the colon. Gas-forming organisms, such as the *Bacillus welchii*, or acid-forming ones, such as *Bacillus acidophilus*, may occur. The predominance of one group or another may be affected by changing the content of the diet — a protein diet favouring the development of one sort, a starch diet another. The *Bacillus acidophilus*, which has recently been exploited as a desirable organism, succeeding to the place of Metchnikoff's *Bacillus bulgaricus* as the organism to prolong life, is a normal inhabitant of the colon, whose increase can be stimulated by using an exclusive lactose or milk-sugar diet for a few days.

So long as the normally acclimatized bacteria are present and only inside the intestine, they do no harm and "do not produce metabolic processes widely at variance with the well-being of the host." "Toxic or irritating metabolic products tend to arouse the antagonism of the host" (Kendall), and therefore are neutralized or destroyed. Some years ago Metchnikoff, the director of the Pasteur Institute in Paris, stirred up a great deal of discussion by suggesting that old age was brought on by the absorption of the products of the proleolytic group of organisms. He thought that the extreme old age attained by Bulgarian peasants was due to the use of sour goat-milk and the growth in the colon of the milk-souring bacterium *Bacillus bulgaricus.* Recently the idea has been revived, but it is now shown that the *Bacillus bulgaricus* does not grow naturally in the colon at all, but that it is easy to implant the *Bacillus acidophilus.* This is best done by drinking milk containing high bacterial counts of the *Bacillus acidophilus.* That it helps cases of constipation and of diarrhœa is undoubtedly true, but that prolongation of life or even any change in the health of normal individuals is brought about by its use is, of course, a pure hypothesis.

The bacteria normally occurring in the intestine may, however, do a great deal of harm if they happen to get outside. The most frequent way of their doing this is to issue into the peritoneal cavity through a perforation — either a perforation of an ulcer of the stomach or intestines, or a gunshot wound. From what has been said it will be seen that the lower down the intestinal tract a perforation occurs, the more dangerous it is. The stomach containing very few organisms, a perforation of its wall does not result in peritonitis for several days, but the perforation of the lower part of the small intestine or the colon allows highly septic material to be thrown out into the peritoneum immediately. The normal bacteria of the intestine, the colon bacilli, can also invade the tonsil-like crypts of the appendix, and when the opening of the appendix into the colon is pinched off, they develop, resulting in appendicitis. The colon bacillus may also wander outside the intestine by way of a special chain of lymph nodes, lighting in the pelvis of the kidney and causing what is called a colon-bacillus pyelitis or a colon bacilluria.

One of the important generalizations about disease is wrapped in this fact that the inside of the digestive tube and the surface of the skin (likewise the nose and throat) contain many bacteria while the organs in between, as it were the really internal organs, are free from bacteria. When the bacteria on the skin or within the digestive tract get beyond their normal habitat, trouble ensues.

The commonest site for infection inside the abdomen is the vermiform appendix. The appendix is a small vestigial structure which in herbivorous animals is as long as the rest of the large intestine. In man it is largely composed of lymphatic tissue like the tonsils. Lymphatic tissue is easily invaded by germs. When germs get into the lymphatic tissue of the appendix, the resulting inflammation is called appendicitis. Appendicitis may be of varying grades of intensity. A mild catarrhal inflammation can be the extent of it. Or the infection may go on to the formation of pus. The pus may stay inside the appendix or it may perforate through it into the peritoneum, with abscess formation and peritonitis.

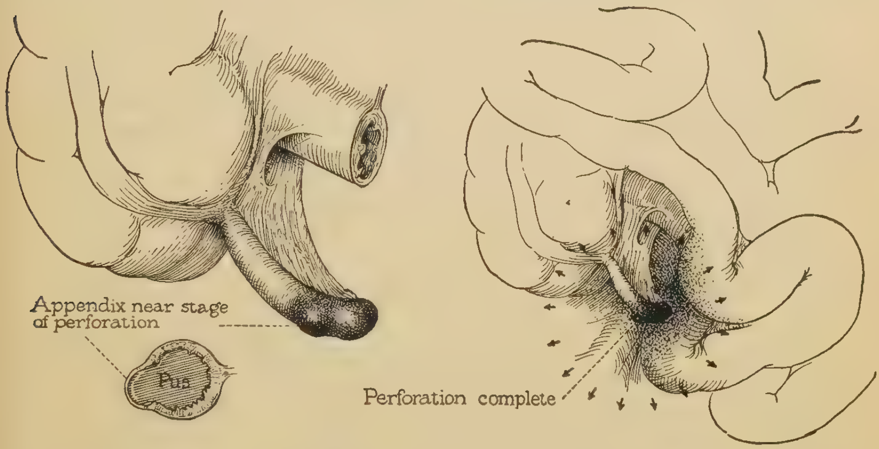


FIGURE 24

Acute appendicitis. At the left, the inflamed appendix with a collection of pus at one point about to break through the appendix wall. Below, a cross-section of the appendix showing the contained pus about to eat its way through the wall.

At the right, the general situation after perforation has occurred. The pus with its contained germs has infected the peritoneum in the region of the appendix. If stirred up, especially by cathartics, *it will spread. Operation should be done before this stage is reached. But note how the large and small intestinal loops are forming a protection against the spread of the pus. Nature's protective device.*

The symptoms are usually quite definite. Dr. Murphy of Chicago used to trace them with that fiery eloquence which made all his pronouncements so vivid. The symptoms follow each other in definite order. The first symptom is always pain. The pain is not near the appendix but in the pit of the stomach. Thence it goes to the region of the navel and thence to the appendix region. The next symptom is nausea, followed by vomiting. The next symptom is fever. Tenderness and rigidity over the appendix region are now evident. An increase in the white cells of the blood, or leucocytosis, is the result of the general infection and is of diagnostic importance.

Treatment of appendicitis is not so completely summed up by saying "Surgery" as is popularly supposed. Acute appendicitis is still a dangerous condition, and operation in the acute stage still has a high mortality. Removal of the appendix in the interval between acute attacks — for this reason called interval appendectomy — is, on the contrary, one of the safest of operative procedures. Many surgeons for this reason believe it is best to allow the patient to get over the acute attack before operating. The handling of the acute attack, however, requires a very definite knowledge. It consists in doing nothing. But the doing of nothing must be done so positively as to require great skill. Especially *do not give a cathartic.* This piece of wisdom is one of the most difficult to impose upon household doctors. If a member of the family has a pain in the abdomen or abdominal cramps, there is always the amateur doctor ready to prescribe a dose of salts or castor oil. It may be stated in the most positive terms that in every serious acute abdominal complaint a cathartic is dangerous. And no amateur doctor can tell whether a given case of abdominal cramps is serious or not. The only safe rule is never to give a cathartic for an acute abdominal complaint.

In an attack of acute appendicitis no food should be taken by mouth and no water except in very small sips. The object of these precautions is the same as the object of withholding cathartics, which is to prevent any intestinal movements. Any substance taken into the stomach starts stomach and intestinal peristalsis. These movements, when they reach the spot where the inflamed appendix is, spread the infection around over the peritoneum, break up the natural defences nature has built up to limit the infection, and will even cause rupture or perforation of the appendix. The time for operating in a case of acute appendicitis is determined by the judgment of the surgeon.

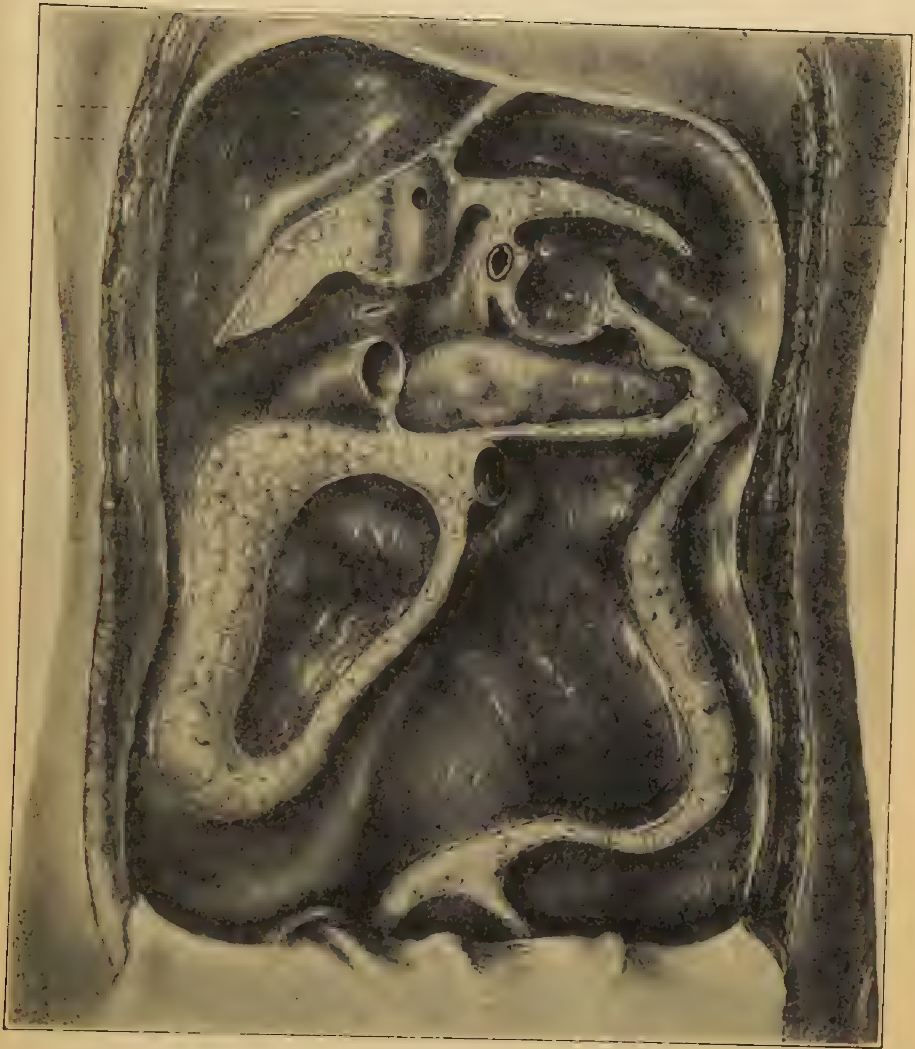


FIGURE 25

The peritoneal cavity with all the organs dissected away.

This brings us to the subject of the defence reactions of the peritoneum. The peritoneum is a serous membrane which has a high power of absorption. Any bacteria with their products which begin to develop inside the peritoneum will therefore cause a very dangerous state. The contents of the gastro-intestinal canal, with their high content of bacteria, can create such a condition should they get from the inside of the canal to the peritoneum. Perforation of an acute appendix, perforation of a stomach ulcer, and perforation of an intestinal ulcer are methods by which the contents of the gastro-intestinal canal get into the peritoneum. When such a perforation occurs, or any other form of infection, the peritoneum attempts to protect itself by gluing the infection into a small mass. Thus loops of intestine surround the infection and grow together. An important part of the peritoneum in doing this is the omentum, an apron of fat which hangs from the stomach and wanders from one part of the peritoneum to the other wherever irritation exists. The gluing together of the intestinal loops and the attachment of the omentum at these spots eventually result in adhesions.

THE LIVER

The LIVER is one of the largest organs, indeed the largest solid organ, inside the body. It must have a number of important functions, but we are in considerable doubt about some of them. We know, of course, that it secretes bile, which is poured into the intestine, but the role of bile in the processes of digestion is very unimportant and we can hardly believe that so large an organ as the liver can persist for so inconspicuous a function as bile production. The liver in fact seems to be an intermediate organ performing functions which are partly digestive, partly concerned in the processes of nutrition, and partly concerned with the cycle of the life of the red blood-cells. The structure of the liver under the microscope shows that it is made up of cylindrical lobules, which are extremely cellular, the large cords of liver-cells radiating from the centre of a lobule, like the spokes of a wheel. We remember that all of the blood which comes from the intestine passes through the liver, brought by the portal vein, before it goes out into the general circulation. Thus all the end products of digestion (except the fats, which are absorbed by the lacteals and go through the thoracic duct to the left innominate vein) are carried first to the liver. It is logical to assume that the liver-cells either prepare them or store them until needed by the body and that this is their main function. We know positively that all the starch and sugar foods are stored in the liver in the form of glycogen or animal starch. With protein metabolism we now know the liver is concerned, since Mann at the Mayo Clinic has shown that the liver is the main organ for the formation of urea. There is another significant anatomical fact about the liver — its close blood-vessel association with the spleen. In disease conditions when the spleen enlarges, the liver does also. It is probable that their functions are closely allied and their separation in the body is purely accidental. These double splenic and hepatic functions are probably concerned with the destruction of red blood-cells, the spleen destroying the outworn cells, and the liver excreting the waste. One of the liver's other miscellaneous, but very important, functions is the production of fibrogen, the substance which initiates the coagulation of blood. If we did not have that substance inside of us, we should be very unhappy people.

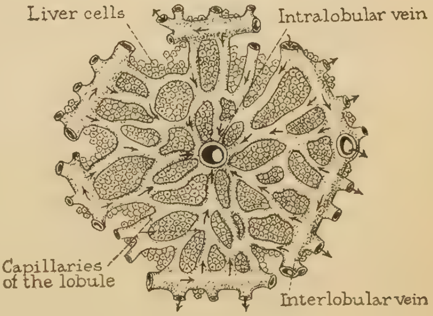


FIGURE 26

A lobule of the liver, diagrammatic. The blood in the interlobular vein has come directly from the intestines. Note that it passes in thin-walled capillaries across the lobule so as to be in direct contact with the largest possible number of liver cells: the capillaries empty into the central, or intralobular, vein, which joins with other veins to form the hepatic veins: these empty into the inferior vena cava, which empties into the right side of the heart. By this arrangement the cells of the liver act upon the blood which comes directly from the intestines, abstracting sugar and other substances from it.

Removal of the liver in animals has taught us much about its functions. It is absolutely necessary in order to maintain life. An animal with the liver removed lives only a few hours. Its life may be prolonged for some time by injecting glucose into its veins, so that it is concluded that the main function of the liver is the maintenance of the normal level of sugar in the blood.

DISEASES OF THE DIGESTIVE SYSTEM

DYSPEPSIA and INDIGESTION are terms which will be found in the older treatises on medicine, those of fifty years ago. They are not used much any more, because it is the habit of the scientific medicine of our day to analyse a symptom or a group of symptoms down to causes. But it suits my purpose to retain them because I cannot go into a discussion of all the diseases of the digestive system, and I want a somewhat comprehensive word such as "dyspepsia," which includes a number of derangements referable to the digestive system, in order that I may touch on the various causes. In general we may say for our purpose that dyspepsia is any feeling or set of feelings referable to the digestive system, especially the stomach, which the owner of that particular digestive system considers wrong. It includes nausea and vomiting, either occasionally or frequently, even the vomiting of blood; sensations of pain or discomfort after meals, as if the food eaten were not happy in its new surroundings or were not being shown proper hospitality; eructations of gas, called on my own native heath "belching"; in other cases loss of appetite, bad taste in the mouth, and a disposition to regard the world as a place to make people stop having a good time in. A furred tongue, a leaning towards the sterner forms of Presbyterianism, and a moist and lubricious yearning to let Mrs. So-and-So know just what her husband does on lodge nights are not infrequent complications.

In order to explain these phenomena there has grown up over the world a naïve formulation to the effect that the consumption of certain kinds of foods will in the course of time permanently injure the stomach and its method of functioning. To the adherents of this canon the eating of articles of food which are in their Index Expurgatorius simply initiates an entrenched warfare between the food and the internal economy of the eater, with the odds greatly against the mucosa of his stomach. I have an uncle by marriage who, being a Virginian, consumed large quantities of hot bread and pancakes. All of my family, being of the cold-bread-eating genus, looked upon this as a direct challenge to the forces of nature. After he married into the family, his consumption of hot bread was looked upon with an ominous head-shaking that impressed me deeply. When a little later in life he developed a severe dyspepsia, my mother and my aunts regarded it as a personal triumph. It was all due to eating hot bread. As I look back on the event now, I can see that he simply developed an ulcer of the stomach, which happens in cold-bread-eating persons with equal frequency, but my entire youth was embittered by warnings against the use of hot bread. The creed takes several forms. One of these is that certain opposite articles of diet are incompatible and will cause indigestion when eaten together. Pickles and ice-cream, for instance. Of course pickles and green apples, another suspicious character, have large amounts of residue which is not transformed by the digestive juices at all and which stimulates peristalsis, or cramps, and which shortly is ejected from the intestines entirely. Why this process should be called indigestion any more than the similar cramps initiated by a cathartic or why it should be regarded as any more harmful is difficult to say.

The entire doctrine is thoroughly expounded in a book I find on my book-stall, entitled *Your Foods and You* by Ida C. Bailey Allen. The introduction reads:

"Why do we lag in the race?

"Why are fifty per cent of us inefficient?

"Why are a third of our school-children under par?

"Why are we old before our time?

"There is but one answer:

"The wrong Diet is responsible."

Now, of course, this is simply bosh. The "one answer" is a characteristic touch. There is no one answer to anything. Thomas B. Reed once said: "People will tell you the truth is simple. Half-truths are simple. The whole truth is the most complicated thing in God's universe."

All kinds of foods are utilized by the body. The body is a very canny old party and can turn nearly anything put inside of it, except what is actually poisonous, to good account. The fact is a certain proportion of the population feel bad all the time, and a certain proportion of the population feel good all the time, but the majority of the population do not think either one way or the other about their bodies except when actual organic illness occurs. The ones who feel bad, however, are always seeking for some explanation of why they feel that way. One of the many explanations they light on (we shall examine some of the others in the course of this tract) is that they do not eat the right kind of food. This cannot be true, because the rest of the population, those who feel good and those who do not feel at all, eat exactly the same kind.

This is not to say, of course, that people with actual organic disease of the stomach, such as ulcer, are not made more uncomfortable by certain kinds of foods than by others. Of course they are. Nor is it to say that some people are not sensitive to certain kinds of foods, the eating of which gives them diarrhœa and hives. Of course there are such people. Nor is it to say, finally, that there is no such thing as food-poisoning from partially decayed or infected food. That too occurs. But it is to say that most food-faddists are half-educated cranks. No one is "chronically poisoned" by certain kinds of foods and no one has his digestion ruined simply by eating certain kinds of food. In general what you want to eat will be good for you. "What one relishes nourishes" was a maxim of Poor Richard. Instinct is a wise physician. The appetite is a wonderfully sensitive instrument, a safe compass. It keeps most of us exactly where we ought to be in weight and strength.

The causes of dyspeptic symptoms may be put down in five classes:

(1) Organic disease of the stomach.
(2) Reflex from other parts of the digestive system — such as the dyspepsia of gall-stones, cirrhosis of the liver, and pancreatitis.
(3) Reflex from parts of the body outside the digestive system — such as the indigestion of tuberculosis, the vomiting of pregnancy, the vomiting of brain tumours, etc.
(4) The bodily habitus — the dyspepsia arising from the low-hanging stomach and bowel of the thin asthenic type of body considered in the first part of the book.
(5) Functional or psychic dyspepsia; the neurasthenic, the neurotic with an organ fixation, a disease pattern, deeply impressed upon the brain, convinced that his or her digestion is intricately, hopelessly, and mysteriously out of kilter.

Let us consider them briefly in this order.

Organic disease of the stomach occurs surprisingly infrequently considering how often complaints about the stomach are made. The only common organic diseases — and by that we mean changes from the normal or average which we can actually see and feel either at operation or after death — are ulcer and cancer.

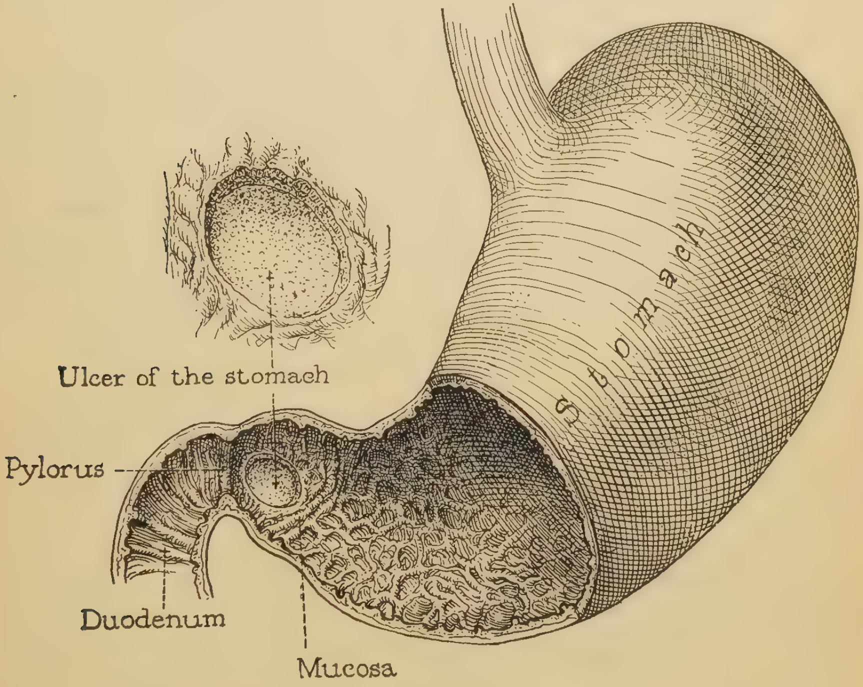


FIGURE 27

An ulcer of the stomach (shown in the usual location, just at the pylorus, or exit of the stomach).

Ulcer of the stomach or of the duodenum (and they can conveniently be considered together) is one of the commonest chronic diseases. An ulcer can occur only on an epithelial or mucosal surface. It consists of a denudation of the epithelium or mucosa over a certain area exposing the parts beneath. In the stomach and the first part of the intestine, the duodenum, these round, punched-out-looking solutions of continuity of the mucosa may occur. For various reasons they become chronic and heal with difficulty in the region of the outlet of the stomach, the pylorus. The cause of them is not determined. One of my associates is perfectly certain that infection in tooth-roots and tonsils throws out germs which circulate in the blood and light in the deep layers of the mucous membrane of the stomach, causing these layers to slough off, leaving the ulcer. There is also associated with ulcer a great increase in the amount of hydrochloric acid in the stomach contents. This irritating condition certainly keeps the ulcer from healing even if it does not cause the formation of the ulcer; that was Dr. Sippy's theory of it: the gastric juice digesting the stomach. In the famous Sippy treatment, therefore, great dependence is put upon the use of alkalis such as bicarbonate of soda and milk of magnesia by mouth, in order to neutralize the excessive acid secretion.

The symptoms of ulcer of the stomach and duodenum are very characteristic. Sir Berkeley Moynihan, perhaps for sheer brilliance the greatest surgeon living, says that the patient in telling his story seems to be trying to recite the symptoms of ulcer as he remembers them from having read them in a text-book on medicine. Pain, or, rather, a sense of discomfort or rawness, referred to the pit of the stomach, coming on in the case of the stomach ulcer right after meals, in the case of the duodenal ulcer when the stomach is empty or just before meals, is the main symptom. There are three serious complications. The commonest is hæmorrhage, the patient vomiting a large amount of blood. The blood is dark and granular in appearance, on account of its exposure to the gastric contents; it has been called coffee-ground vomitus. Perforation, in which the ulcer eats its way clear through the stomach wall, allowing the stomach or duodenal contents to escape into the peritoneum, is of the utmost seriousness because of the peritonitis which follows. It demands immediate surgery. Fortunately its symptoms, such as pain, shock, and collapse, are so striking as to call attention to itself immediately and indicate the need of assistance. The third complication is narrowing, or stenosis, of the pylorus (the outlet of the stomach), caused by the progressive contraction of the ulcer in healing. In treating the last condition surgery is the most valued aid, the surgeon by the operation of gastro-enterostomy making a new outlet for the stomach at its lowest point.

The treatment of simple, uncomplicated ulcer is, besides the use of alkalis already mentioned, the institution of a diet. The diet should consist of food which has the highest combining power with hydrochloric acid and the lowest irritating power. Milk, cream, and eggs are among such articles. Lean meat, mashed potatoes, well-cooked oatmeal, and cream soups also are well tolerated. Bread, unless it be toasted or stale, sweets, fried foods, heavy vegetables, and fruits in general are very irritating.

Cancer attacks the stomach about the third or fourth oftenest of any spot in the body — the uterus, the breast, and the skin being the other favourite sites. We shall consider the characteristics of cancer at another place.

Reflex dyspepsia may arise from disease nearly anywhere. The stomach has been called the greatest liar in the anatomy, meaning that it complains or shows symptoms when the real trouble is far elsewhere. Among frequent origins of such symptoms is the gall-bladder. The reason for the frequency of gall-bladder disease is that the liver receives all the blood coming from the intestine: the intestines constantly receive all the bacteria swallowed, and at times some of these are harmful, sometimes escape and make their way to the liver; the liver excretes them in bile, and this bile is retained temporarily in the gall-bladder before it makes its way out to the intestine. Thus the gall-bladder is constantly subject to infection and few gall-bladders escape it. Several different things may happen when gall-bladder infection has occurred. The walls of the gall-bladder may become infected and a mild inflammatory process, limited largely to the mucous membrane of the gall-bladder, may go on for years. Mild dyspeptic symptoms possibly occur. The formation of gas in the stomach seems to be particularly associated with gall-bladder affections. The process may go further and pus form in the gall-bladder. A more usual thing is for stones to form. Stones will form anywhere in the body where there is a fluid containing salts that can be crystallized, and where the fluid is for a time retained in a hollow organ. Thus stone in the bladder and stone in the kidney are frequent. The salts held in solution in the bile are as a rule fatty organic salts, and gall-stones are generally soft in consistency — so soft that they can be scratched or even split open with the finger-nail. The salts composing them form around a collection of germs, or germs and mucus. The stones may be very small or large, they may be single or multiple. Naturally the symptoms of gall-bladder disease will depend upon the nature of the pathologic conditions present. Small stones are likely to get outside the gall-bladder itself and begin to migrate in the cystic and common ducts towards the intestine; this results in gall-stone colic, one of the most excruciatingly painful sensations to which flesh is heir. Sometimes a stone gets stuck in the common duct, and jaundice results.

The only successful treatment of gall-bladder disease is surgery. Of course nature often takes care of the condition herself, the gall-bladder in time shrivelling up, ceasing to function, and thus burying its contained stones. Often the gall-stones may be perfectly silent. We frequently open bodies and find that the gall-bladder is full of stones though the deceased made no complaint during life. These facts explain all the medical cures and gall-stone solvents.

But the work of surgery in this field has been a great triumph. It is the minor improvements that have made life more endurable. When we are moved to point to the advantages of living in the twentieth century, we are inclined to mention the steam-engine, and forget spectacles. Why praise telephones, the most damnable of all inventions, with their constant whirring of bells and their opening of the privacy of your home to any fool who has a nickel, and ignore brass plumbing?

In this connexion compare the gentleman in the eighteenth century who suffered from gall-stones. What happened to him? Why, he suffered. He might have called in the best practitioner of his day. What then? He still had gall-stone colic and cramps. There was no morphine (morphine is dated from 1817). There was no hypodermic syringe even if there had been morphine (the hypodermic syringe is dated from about 1847). Supposing there was opium, it is more than likely, if he had a gall-stone colic, he would vomit the opium if administered. In other words, if he had a gall-stone colic, he just had a gall-stone colic, that is all. Perhaps he had another one and had jaundice; then what? Well, he would be told gravely that he was bilious, and he would be purged. Suppose he went on having the dyspepsia of gall-bladder disease; what then? He would be given the most frightful mess possible to imagine, spiders' legs, toads' entrails, animal dung. I quote by the book, not by obscure quacks — from prescriptions of Gideon Harvey, physician to His Majesty King William the Third, Prince of Orange and Defender of the Faith; of John Radcliffe, physician to Queen Anne; of Cheselden, physician in ordinary to His Most Sacred Majesty George the First of England. Their books, still sold at auctions, have all such remedies in them and, reading them, it is evident to me, an obscure student of a later time, that their patients had gall-bladder disease, but it is also perfectly evident that *they* hadn't the slightest idea what was the matter.

Suppose, comparatively, that to-day a retail dry-goods merchant of Watumwa, Idaho, should be seized with the same complaint. The most weather-beaten practitioner he would be likely to call in could see at a glance that the trouble was gall-stones. The patient would be removed to a clean and pleasant room in a hospital. His abdomen would be shaved. An anæsthetic would be administered to deaden his mind. Any one of five competent young men setting themselves up to be surgeons would be called in to remove his gall-bladder and its stones. Any one of the five would do it equally well. He would be separated from his disease. His gall-stones would be put in a bottle. He would be put back to work. He would talk about his emotional experiences under the anæsthetic for several months. Would he have run any risk? He would have. About the same amount as in crossing Fifth Avenue at Fifty-third Street under the influence of one highball and the direction of his wife.

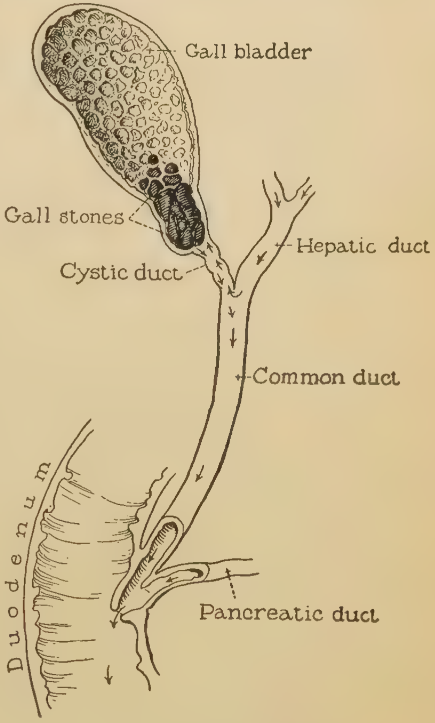


FIGURE 28

Gall-stones in the gall-bladder.

This is the surgery of dyspepsia.

CONSTIPATION is the only other common derangement of the digestive system of which I have space to treat. After a meal the food should leave the stomach in six hours. Some of it begins to leave immediately, so that the remnant of a meal traverses the small intestine and reaches the cæcum in from four to six hours. It gets to the hepatic flexure of the colon in six to eight hours, to the splenic flexure in nine to nineteen hours, and to the sigmoid in twelve to sixteen hours. Twenty-four hours after the meal is ingested, the food mass of that meal is usually just above the rectum ready for ejection. The act of defecation itself is somewhat more complicated than is generally considered. The rectum under normal circumstances is always empty. A valve-like structure separates the rectum from the sigmoid, and the fæcal mass stays just above this. The character of the inside of the bowel in the sigmoid region is different from that in the rectum. The rectum is better supplied with sensory nerves and transmits the sensation of fullness to the consciousness. With the pushing onward of the next meal the fæcal mass in the sigmoid is thrust into the rectum; its presence is made known to the brain in the desire to go to stool. This call to stool is most likely to occur after breakfast, because during the night the food mass has accumulated in the sigmoid and the first meal starts a gentle peristalsis of the entire bowel, which, reaching the sigmoid, propels the fæcal mass into the rectum. In some people this movement is sluggish and insufficient to thrust the fæcal mass into the rectum every day.

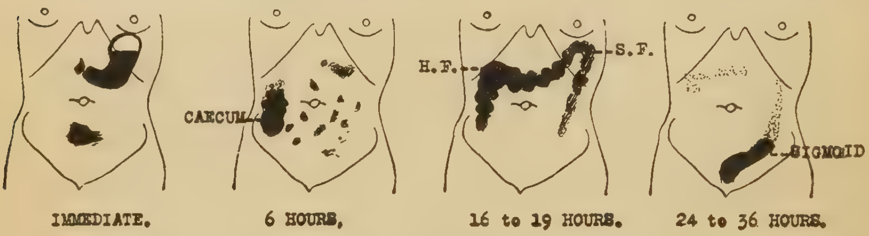


FIGURE 29

Time schedule of the passage of food through the intestine. Observations by the X-ray with an opaque meal (made opaque to the passage of the X-rays by barium, a non-absorbable chemical). In the first figure the outline of the stomach as seen in the X-ray may be observed: there is always an air bubble at the top of the stomach. In six hours the meal has almost left the stomach: some of it is still in the small intestines (segmented): a part of the meal has reached the first part of the large intestine, the cæcum. H. F. — hepatic flexure of the colon. S. F. — splenic flexure of the colon.

It may have to accumulate two or three days, until its bulk is sufficient to stimulate peristaltic action enough to move it into the rectum. It does no harm whatever remaining in the sigmoid, as absorption from the sigmoid into the blood-stream is almost nil. There is no law of nature stating that the bowel must be evacuated every twenty-four hours. Individuals vary in this. When the head of the fæcal mass enters the rectum, the call to stool lasts only a short time. If unregarded, the fæces again recede into the sigmoid. While in the rectum, they can be evacuated by the voluntary effort of the individual — the exertion of pressure by the abdominal muscles and the pushing down of the diaphragm. When they are in the sigmoid alone, no amount of straining will move them. Defecation should empty not only the rectum, but also the sigmoid, and sometimes part of the descending colon.

The entire process being somewhat complicated, it may become disordered at any one of several points. The bowel in certain individuals may be more sluggish than in others, and the fæcal mass move more slowly. The sensitiveness of the rectum may be diminished in some, or dulled by disregard. Rectal disease, such as hæmorrhoids (piles) or fissures, may cause rectal spasm and keep the fæcal mass from entering the rectum.

Constipation is the favourite topic of amateur health-faddists and amateur doctors. In their sermons it takes on lurid aspects and becomes veritably the root of all evils. I quote in evidence from one of the voluminous treatises of Alfred W. McCann (*The Science of Keeping Young*): "We multiply at will the indescribable depression begotten by the retention of fatigue poisons in auto-intoxication." Books on purifying the colon, and regulating the colon, and preserving health through keeping the bowel in order, and intestinal gardening, crowd booksellers' stalls. One of the most insidious of these monographs is entitled *The Lazy Colon*, by Charles M. Campbell and Albert K. Detwiller, M.D. It is advertised in the *Literary Digest* for June 5, 1926, with a recommendation in letter form from Judge E. H. Gary. The Judge's photograph is reproduced in order to give point to the laudation. He is resting his head upon his hand in the attitude universally recognized the world over as that assumed during the act of deep thought. It is a perfectly logical assumption that a man who has made a success of the steel business is a good critic of a technical

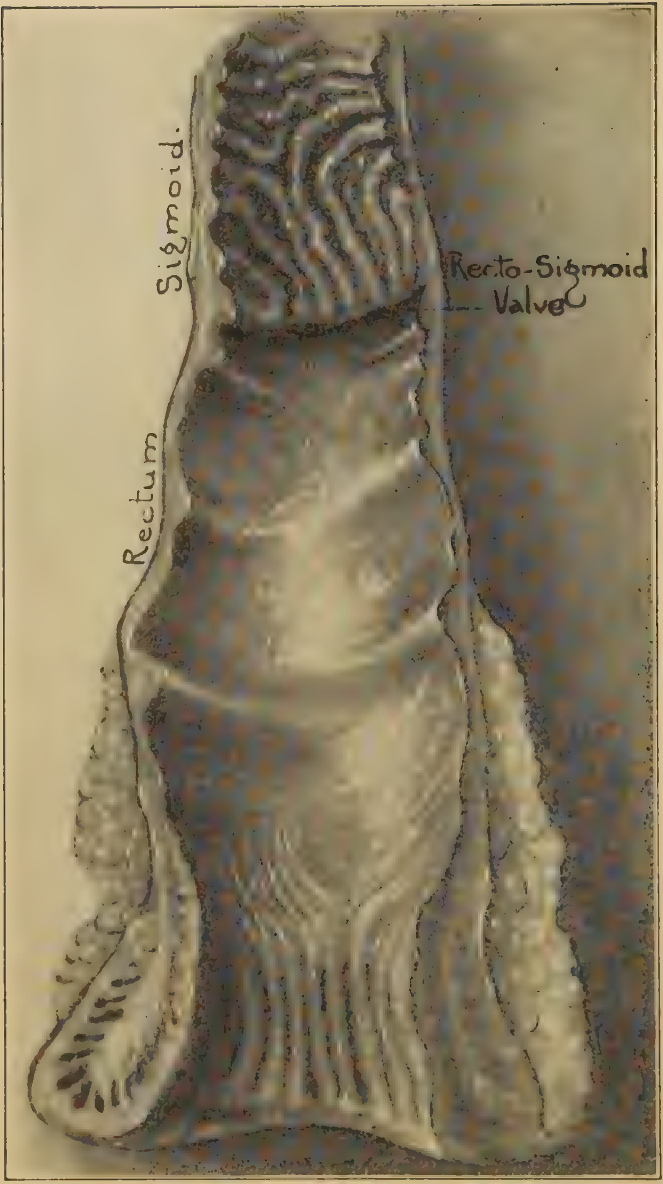

Sigmoid.
Recto-Sigmoid
Valve
Rectum

FIGURE 30

The differential anatomy of the rectum (After W. J. Mayo.)

problem in biological chemistry. Therefore the Judge's praise of a book which promises to throw a new light on good complexions, baldness (the Judge's photograph unfortunately shows him perfectly bald, but presumably he did not get the book in time), longevity, bad teeth, and self-poisoning has great point.

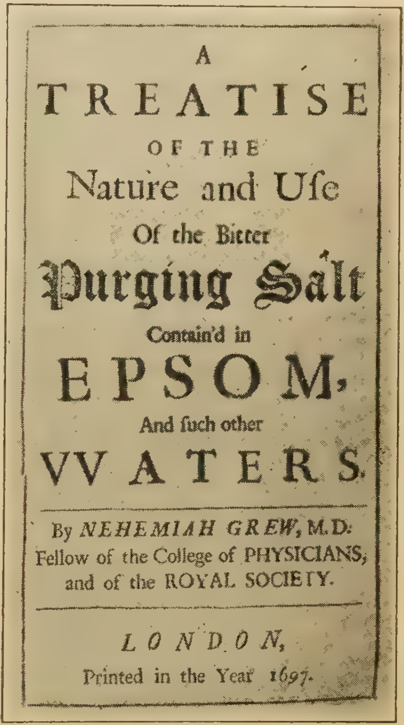
Patients are easily infected with the doctrine. They tell me: "Constipation had added ten years to my life," or "All my melancholy and continuous fatigue are due to constipation." Sir Arbuthnot Lane, a London surgeon, some years ago wrote treatises to show that constipation is the cause of neurasthenia, exophthalmic goitre, ulcer of the stomach, cancer of the breast, tuberculosis, and I do not know what all besides. He thought everyone should have his colon out. He did not have his own colon out because he said he had a very good colon, or something of that sort. Many physicians thoroughly believe this doctrine that constipation is the root of all evils.

My own experience has been curiously at variance with all this. Most of the people whom I have examined carefully who say they have constipation are not constipated at all. The experience is becoming quite monotonous. A patient presents himself to be treated for constipation. The examination is conducted in this manner: the patient is given an opaque meal so that its course can be timed through the gastro-intestinal tract. It is swallowed, say, at 10 A.M. on Monday. At 4 P.M. the patient is seen again. The meal is noted to have left the stomach and to be in the intestine. The patient is cautioned not to use any cathartic that night, so that the natural rate of the meal can be timed, and to appear the next day at noon. At that time the meal is seen to be in the cæcum and transverse colon. The patient is again warned not to use a cathartic and to appear on the third day. At this time no shadow is seen in the intestines at all and the following conversation takes place: "Did your bowels move this morning?" Answer, in a tone of the greatest astonishment: "Why, yes, I had the first natural bowel-movement I've had for years." The patient had been taking cathartics regularly for years and had never waited to see if the bowels would move naturally without them. The cathartics had kept the inside of the bowel irritated and the sense of fullness, which is the only sensation the mucosa of the intestine can convey to the brain, had made him feel that the bowels were never completely empty. The cause of the constipation was the use of cathartics.

There are some actual cases of constipation, but usually it is a neurosis — a pattern idea of disease, deeply fixed in the mind of childhood. Consider the child's mental attitude towards the evacuation of his bowels. He is enjoined from the very earliest time he can remember that the act must be performed daily. He is always scolded if the bowels do not move, he is always praised if they do. If he is sick, no matter if he has measles or tantrums, the first treatment is directed to opening the bowels. No wonder the thing assumes a central importance in his mind. No wonder, if in after life anything goes wrong, the first thought is directed towards the bowels. No wonder, if on the fatal day they fail to move, a sense of some terrible doom becomes imminent. And then the whole theory seems so reasonable! The bowel-movements have a dreadful odour, due to skatol and indol; they are thoroughly disgusting. They must be just reeking with poisonous matter. If that is cooped up inside the body, and absorbed into the blood, it will simply overwhelm a person with venomous matter. Of course the fact that absorption of such material or any other material, except water, from the large bowel hardly occurs at all, that no matter how often or thoroughly the bowel is flushed out, there is always some of this poisonous-appearing material in it; that after all, noxious as it may appear superficially, fæcal matter is not very toxic, and that the body has through long ages adapted itself so that such material in the bowel will do it no harm, is lost sight of in the mad ride of the hobby once it is mounted. All the symptoms these people have can be explained on the basis of introspection. My friend Alvarez, for instance, formerly of San Francisco, now of the Mayo Clinic, found that he could produce the headache which is always claimed to be relieved by a bowel-movement, and considered certainly to be due to absorption, by stuffing cotton into human rectums. Your bowels, like the universe, will get along very well if you leave them alone. They will adjust themselves to the body they inhabit and the kind of food it eats.

Just as constipation is the disease of amateur healers, so are cathartics their especial drugs. They appeal partly because, unlike many other drugs, their therapeutic action can be so exactly measured. They have been known and used since the earliest times. They assisted the worship of God in the healing-temples of the Egyptians and Babylonians. Plutarch mentions them.

There was a formal Roman custom of purging and vomiting before sitting down to a banquet. The host furnished the cathartics and the emetics. Whether they assisted the expansion of the soul as much as a dry Martini I cannot say.



A
TREATISE
OF THE
Nature and Uſe
Of the Bitter
Purging Salt
Contain'd in
EPSOM,
And ſuch other
VVATERS.

By NEHEMIAH GREW, M.D.
Fellow of the College of PHYSICIANS,
and of the ROYAL SOCIETY.

LONDON,
Printed in the Year 1697.

FIGURE 31

A landmark in the history of mankind. Title page of the book which first described the action of Epsom salts.

Many cathartics have been discovered by accident. Epsom salts (chemically, magnesium sulphate) were discovered on Epsom Downs in 1618. A farmer, so the legend goes, whose very name, Henry Wicks, has been preserved, tried to water his oxen at a spring on the Downs, but found to his surprise that the oxen would not drink. He himself tasted the water and found it salty and bitter. Naturally, he talked at the fireside and the inn about his strange discoveries. The local townspeople began to use the water externally for sores and ulcers on the skin, a use to which it is still put. A nobleman, Lord Dudley North, was the first who had the courage to use it in quantity internally, demonstrating its cathartic properties and announcing his exalted body much benefited. Stimulated by the naturally superior pronouncement of an intellect inhabiting the House of Lords, "society flocked" — again I quote the legend — "to Epsom to partake of the waters." Epsom after this start had many spells of alternate prosperity and decline. In 1720 "gaming, with every other description of profligacy and vice, prevailed to an enormous extent." An alluring prospect, though as a physiologist I am unconvinced that these loose activities had any association with the laxative effect of the spring. In 1736 "a female bone-setter," Mrs. Mapp, "instilled," as such ladies always do, "a temporary interest," but in 1754 the proprietress of a tea-room announced, with an easily discernible note of pathos, a recognition that Epsom's glories were departed, under a newspaper advertisement of "Epsom's Old Well," but added that in spite of the decline "a genteel assembly had breakfasted at her place on Monday," merely adding as a "Note — The purging waters of this place are in excellent order." They still are, it is comforting, at least to me, to think, and to consider that they have the same effect upon my humble bowels as upon the lusty intestines of those magnificent swingebucklers and the exquisite colons of the gaudy belles who simpered at one another at Epsom in the heyday of the reign of George III.

One of the newest cathartics, phenolphthalein, has an interesting history. It has long been used in chemical laboratories as an indicator, because it has the property of turning red in the presence of alkalis and remaining colourless in the presence of acids. A few years ago the Hungarian Government passed a statute that white wines have phenolphthalein added to them in order that adulteration could easily be detected. The phenolphthalein up to that time was supposed to be harmless and to have no therapeutic action. An epidemic of diarrhœa spread over Hungary as a result of the carrying out of the order, and it was shown that phenolphthalein had moderately strong cathartic properties. It is a good cathartic for children because it can be disguised in candy and chewing-gum — phenolax, zam zam, purgen, phenalin, purglets, purgo, ex-lax, etc. I once had a rather interesting personal experience with an amateur magician. After every one of his performances he had a diarrhœa. We found that he did a water and wine trick — pouring water and wine alternately from a glass pitcher containing water. The water was alkalinized with sodium bicarbonate, and each alternate glass, the ones in which the wine was to appear, had a few drops of phenolphthalein in them. After the pouring he would drink off a glass of the supposed wine before the audience with great relish and gusto. Followed the diarrhœa.

Senna is a favourite cathartic because it too can be made up into a sweet mass. It is the active ingredient of Syrup of Figs, Castoria, and suchlike remedies.

Perhaps the best form of catharsis for a single evacuation is calomel at night and a salt — preferably, in my opinion, a bottle of magnesium citrate — in the morning. The calomel acts only on the small bowel, the salt on the large bowel.

For chronic use, for the person who has a sluggish intestine, and such cases do occur occasionally, I recommend cascara — the fluid extract. Not the aromatic or sweetened fluid extract, which is only one fourth as strong, but the bitter fluid extract. Being in liquid form, the dose can be adjusted so that the exact number of drops are taken at night to produce a formed stool, without griping, after breakfast the next morning. The exactness of the dose gives it an advantage over pills.

For most cases of real constipation, however, cathartics should be abjured entirely and dependence put upon using a diet with a large amount of bulk. The vegetables, of course, supply this requirement best. Their cellulose content is not digested in the stomach or intestines and hence remains inside the bowel to stimulate peristalsis. Bran, which can be made into many palatable forms, is a good adjunct of this form of treatment.

THE METHODS OF EXAMINATION OF THE DIGESTIVE SYSTEM for the presence of disease or the determination of normalcy are several. The patient's history, his recital of his sensations and experiences, is by all odds the most important. The diseases of the stomach (see the account of the symptoms of gastric ulcer), of the gall-bladder, of the appendix, and of the intestines present very characteristic methods of onset — so characteristic that all patients tell about the same story. This story, anamnesis, or history, constitutes, by the agreement of all those diagnosticians of the greatest ability, ninety per cent of the valuable data in gastro-intestinal disease.

The physical examination of the whole patient is next in importance. By physical diagnosis is meant the data which the physician can accumulate with his own senses — seeing first of all, feeling second, and hearing last. In diseases of the heart and lungs hearing perhaps holds the post of honour. For digestive diseases it is less valuable. Feeling for tenderness in the abdomen and for rigidity of the abdominal muscles, which always occurs when inflammation is under them, and for tumours, swellings, and lumps is the method of physical examination of choice in the abdomen. But the whole body must be first examined. We emphasized in the paragraphs on dyspepsia that symptoms referable to the stomach might come from disease far away — so the presence of tonsillar and dental disease, thyroid disease, tuberculosis, disease of the nervous system, such as locomotor ataxia, of eye-strain, of pregnancy, must be inquired into and ruled out before approaching the digestive system itself.

Third, laboratory examination of the gastric contents and of the stool are made. These, especially the obtaining of the gastric contents after a test meal, with the concomitant ingestion of a stomach tube, make a great impression on the patient. Once in every humorist's life (see an early protocol of the jocose Irvin Cobb) he visits a stomach specialist and sells the *Saturday Evening Post* an account of the experience, embellished with illustrations by Tony Sarg. But as a matter of fact such examinations yield very little information and are no more valuable than a — "a demnition," as Mr. Mantilini observed on one occasion when he was at a loss for a simile.

The X-ray has contributed greatly to our knowledge of the physiology of the digestive canal, and its use in abdominal diagnosis results in the most important single group of data, after the history, that we can obtain. Œsophageal disease depends almost entirely on the X-ray for elucidation. The outline and emptying-rate of the stomach, the presence of ulcer and especially of early cancer, can be made out by this means. Recently, thanks to the brilliant work of Graham, the outline of the gall-bladder and the presence and absence of stones can be determined with great accuracy.

Function tests of the liver to determine its physiological integrity are known, but have not yet been brought to a stage where dependence can be placed upon them.

Electric-lighted instruments rudely thrust into the œsophagus, the stomach, and the sigmoid yield in competent hands a considerable amount of positive information.

CHAPTER IV

THE RESPIRATORY SYSTEM

Bring a mirror close to your mouth and breathe upon it. There will, as you know, be a film of moisture deposited. Take the rubber bulb from an atomizer and blow the air from it upon the mirror; there will be no moisture. This is the whole secret of the physiology of respiration. The air you breathe out is different from the air you breathe in. It has more water for one thing, as you discovered with your mirror test. What you can't see is that it has more carbon dioxide and less oxygen.

It took men a long time to stumble upon this fact. Inquiring minds had been puzzling about the problem for at least two thousand years before the explanation was discovered. In France just on the eve of the Revolution! And in the most surprising place imaginable — not among the group of intellectuals at all, but in the heart of the aristocracy. Lavoisier, whose valuable head was soon to be removed by the guillotine, was the first to show it clearly. This was in 1777. The title of his paper is significant — *Experiments on the Respiration of Animals and on the Changes which the Air Undergoes in Passing through the Lungs.* The secret was out with that, although John Mayow, one of the very great of the neglected geniuses of England, whom even Mr. Bernard Shaw has not yet discovered, almost splashed into the truth a century before.

The body, remember, is a machine for the production of energy. In a heat machine or a combustion machine, which is what the body is, oxygen is absolutely essential. Every flame consists of a union of oxygen with other elements. Every animal extracts oxygen from the medium in which it lives — fish from the oxygen dissolved in the water and extracted by the gills, insects by sucking in air through a series of individual lung alveoli, separated from each other and placed each in a segment of the insect body.

In man and the other air-breathing vertebrates the lungs are simply modified forms of gills — modified to adapt themselves to the utilization of air. The act of respiration consists, essentially, in having the air brought to a place where there is a very thin membrane between it and blood; the oxygen in the air passes through the membrane and cells, to be carried by them to the tissues. The blood-cells in the mean time have been carrying the by-products of combustion in the tissues, carbon dioxide and water; these separate from the blood-cells, pass through the membrane, and are given off into the lung alveoli and breathed out in expiration.

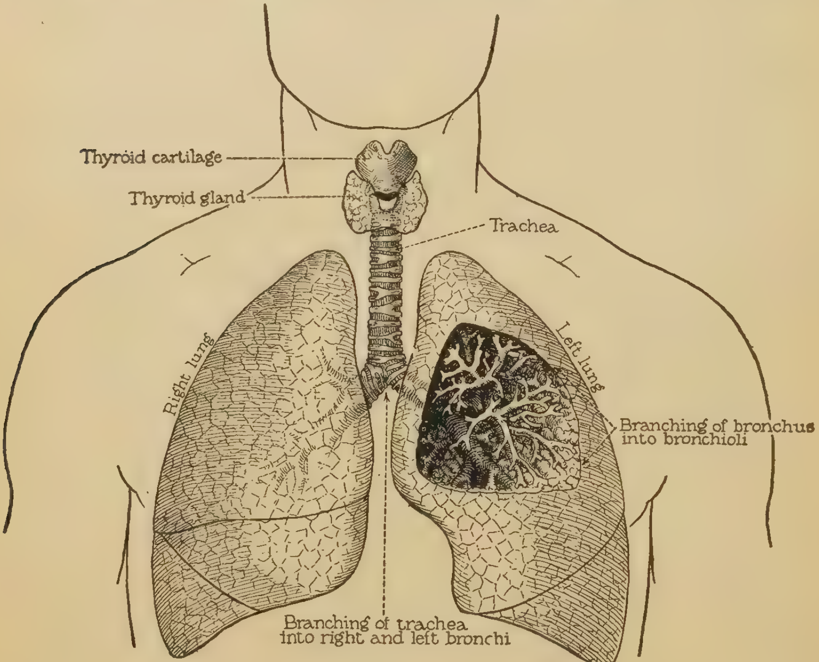

Thyroid cartilage
Thyroid gland
Trachea
Right lung
Left lung
Branching of bronchus into bronchioli
Branching of trachea into right and left bronchi

FIGURE 32

The lower respiratory system.

The need for oxygen is, as a matter of common observation, the one continuously essential bodily need. The body can go without food or water for some time, but not without air. The anatomical arrangements developed for keeping this supply of air unimpeded are very definite. The tube which brings air to the lungs, called the trachea, and its divisions, the bronchi, are surrounded and held open by heavy rings of cartilage, in order that no muscular action or crushing of external objects can compress that absolutely necessary pipe line. Each bronchus divides and subdivides until it gets to its ultimate point, the thin-walled alveolus of the lung. Over the surface of the alveolus the blood from the right heart is spread out in a fine capillary network. The entire lung consists of millions of these alveoli, individual little lungs, each exactly like the other.

The lungs are separated from other organs of the body in a movable rigid box — the chest cavity. It again is protected from collapse by being surrounded by circular hoops — the ribs. It is divided off from the abdomen below by a strong tent-like muscle — the diaphragm. Both the diaphragm and the ribs move rhythmically and regularly in the act of respiration. They move throughout an animal's life. The movements of respiration are partially voluntary — can be changed and directed at will — but are so controlled by a delicate arrangement in the central nervous system, presently to be described, that they are largely automatic and are performed even when the animal is asleep or has its attention directed towards other matters. As the diaphragm moves up and down in respiration, it creates, with the help of the muscles which move the ribs up and down, alternately a low pressure in the chest, so that the lungs have to expand and air rushes in, and a high pressure, so that they collapse and air is expelled.

The division of the large body cavity of vertebrates into two parts — chest and abdomen — is made by the diaphragm. The fact that the body cavity, or cœlom, is divided into two cavities is one of the distinguishing anatomical marks of the higher vertebrates. The diaphragm has been developed, in the process of evolution, from a thin membrane high up in the neck of fishes. In the fish the gills and the heart are close together, close under the mouth. As the gills changed to lungs, and an air-tight compartment was provided for them, they moved downward, the diaphragm preceding them. But, as a matter of the most exquisite interest, the nerve which innervates the diaphragm, the phrenic, still arises high in the neck, and, traversing the entire chest, at great waste, is the string which shows us where the diaphragm originally was and its pathway of migration during the ages. I shall never cease to regret that Mr. Darrow did not get into the record Mr. Bryan's explanation of the queer conduct of the phrenic nerve. If it is an example of omnipotent intelligence as expressed in structure, it is one of the drollest of engineering mistakes.

There are two points at which respiration occurs — for we must consider respiration essentially as an exchange of gases — one in the lungs and one in the tissues. We may call these, using the jargon of the laboratories, external and internal respiration. What actually takes place in either external or internal respiration is by no means simple. Just grasp the elements of the problem. In respiration in the lungs the air, containing in part oxygen, is brought into the alveolus of the lung where it is separated by a very diaphanous membrane from the blood in the capillaries. Here the exchange of gases takes place. The difference between inspired and expired air is given in a table of Howell's *Physiology* as follows:

	Nitrogen	*Oxygen*	*Carbon Dioxide*
Inspired Air...........	79	20.96	0.04
Expired Air...........	79	16.02	4.38

(Figures are volume per cent)

What makes the blood take up oxygen and at the same time give off carbon dioxide and water into the alveolus? Briefly, it is due to the pressure and diffusion of gases. The laws of gas pressure and diffusion have been worked out by the science of physical chemistry. They are of extreme complexity and I can only attempt, for those who do not already know them, a crude description. The actual part of the blood which carries the oxygen is the red blood-cell; the actual part of the red blood-cell which is concerned in oxygen-carrying is a chemical compound called hæmoglobin; and the actual part of the hæmoglobin which unites with the oxygen is the iron content of it. Iron has an affinity for oxygen. Why I do not know. The reason for affinities, human or chemical, is always more or less of a mystery. But there is no question that they exist. The red blood-cell is really a kind of fine-mesh ball of strands of tissue containing hæmoglobin, and just as a mesh ball of platinum will take up certain gases, so does the corpuscle.

When the blood gets to the tissues, something even more mysterious takes place. I do not think that physiologists themselves understand this: they write much too elaborately on it for that. But, at any rate, the red blood-cells with their hæmoglobin loaded with oxygen get to the tissues — out in a tiny muscle-cell in the arm — and there the muscle-cell doing its work needs oxygen to burn for energy. It takes it from the red blood-cell, possibly because the pressure of oxygen in the tissues is very low, while the pressure of oxygen in the red cell is very high. The tissue — muscle-cell — has, however, in doing its work accumulated some ash or smoke. The ash or smoke is carbon dioxide and water — it's much like your own grate-fire smoke — and these are absorbed back into the red cell, which, loaded with its burden of waste, flows back in the veins to the right heart, then once more to the lungs to be re-oxygenated.

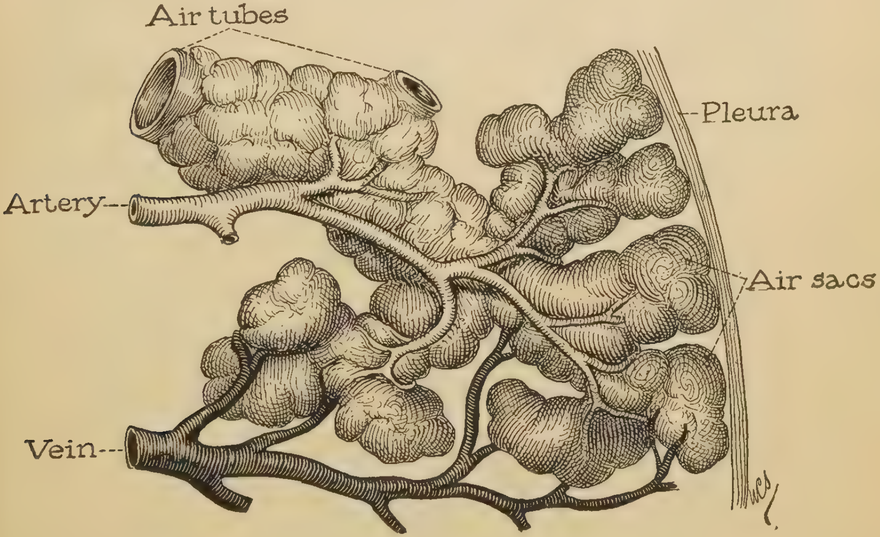


FIGURE 33
An air sac. The end point of a lung branch.

The amount of air (oxygen) which the body needs varies from time to time. Muscular exercise, for instance, calls for more than repose. These varying needs are adjusted by the rate and depth of the respiratory movements. The regulation is wholly automatic and the demonstration of its mechanism is one of the nicest bits of experiment in modern physiology. There is in the region of the large ganglia at the base of the brain, in the medulla oblongata, a respiratory centre. It is bilateral, supplying the muscles used in respiration on each side of the chest. If a needle is thrust into this centre and wiggled so that the nerve-cells are destroyed, respiratory movements cease and death ensues. What keeps this centre sending out regular rhythmic stimuli to the respiratory muscles? What makes it slow those movements when the need of the tissues for oxygen is satisfied? Two English physiologists, Haldane and Priestley, answered these questions completely by their very beautiful demonstrations. They showed that the accumulation of carbon dioxide in the blood caused the respiratory centre to be stimulated so that it sent out impulses to the muscles of respiration, causing more rapid breathing. The centre is very sensitive: if the carbon dioxide accumulation in the blood rises 0.2 per cent over the normal, a rise of 50 per cent in the amount of air respired ensues. Thus, if you hold your breath, the carbon dioxide will immediately begin to accumulate in the blood, the blood of course will circulate through the respiratory centre, and a point will be reached when you have to begin to breathe, no amount of voluntary effort on your part being able to prevent it.

No account of the respiratory system is complete without some reference to the upper respiratory tract, especially the nose. The respired air passes in and out of the nose constantly. Inside the nose is a sort of meshwork of rounded bones covered with thick mucous membrane suffused constantly with a moist secretion. The air in passing in and out over the meshwork is warmed and moistened, preparing it for entering the lungs without the danger of undue cooling or shock to the lung tissue. From the nasal passage several chambers open out, called sinuses, hollow mucous-membrane-lined cavities, each connected to the nose by an aperture. One of these on each side is over the orbit of the eye cavity; this one is called the frontal sinus. One on each side is in the hollow of the bony cheek or upper jaw — the maxillary sinus. The nose, on account of its particular guardian position at the gateway of respiration, is peculiarly liable to infection from the germs in the air. In infants large masses of lymphatic tissue occur in the back of the pharynx or upper respiratory passage; they are called adenoid-tissue, or the adenoids. Helped by the tonsils, they are designed to overcome infection. In adult life this ring of lymphatic tissue gradually atrophies and practically disappears. Nowadays such deletion is accomplished more frequently by the nasal surgeon. It is perfectly natural for these organs to be large in childhood, in fact for the tonsils actually to meet in the centre of the throat.

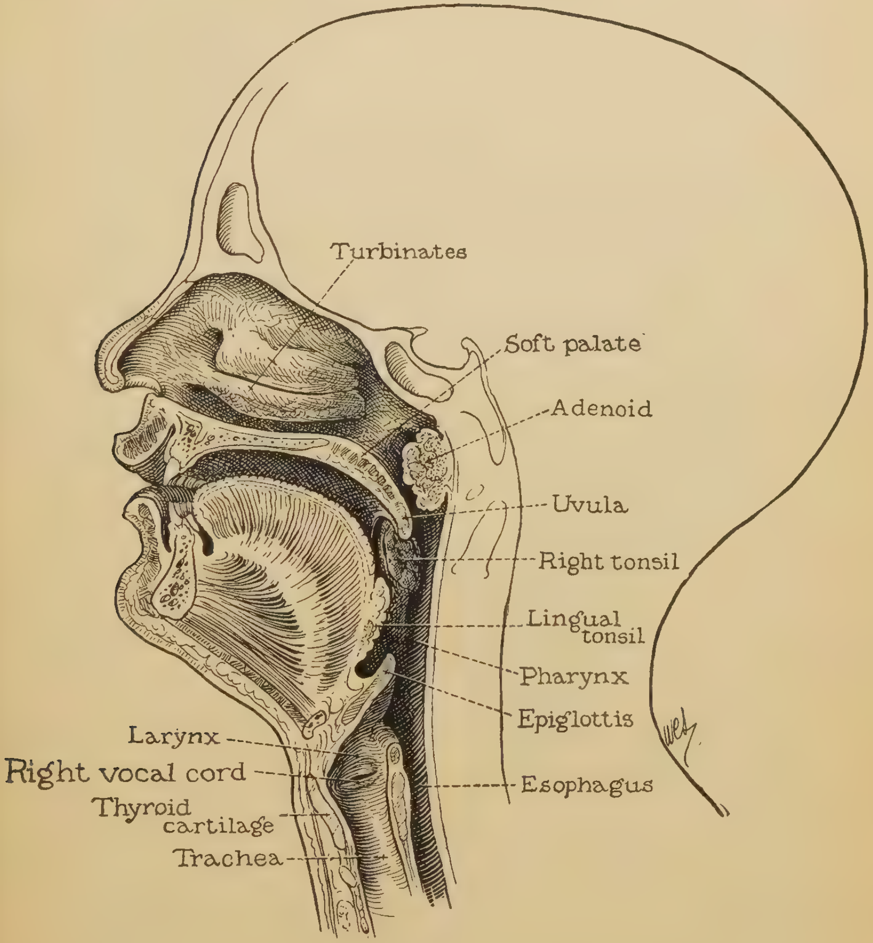

Turbinates
Soft palate
Adenoid
Uvula
Right tonsil
Lingual tonsil
Pharynx
Epiglottis
Larynx
Right vocal cord
Thyroid cartilage
Trachea
Esophagus

FIGURE 34

The upper respiratory system of a child. Note the ring of lymphatic tissue (tonsils, adenoids, and lingual tonsils) surrounding the back of the throat, all larger and perfectly normal in a child.

The fact that they are enlarged is no reason for removing them. If they become infected, as they almost invariably do on account of their peculiar position and function, they can be removed in later life, provided the infection seems severe. The adenoids also

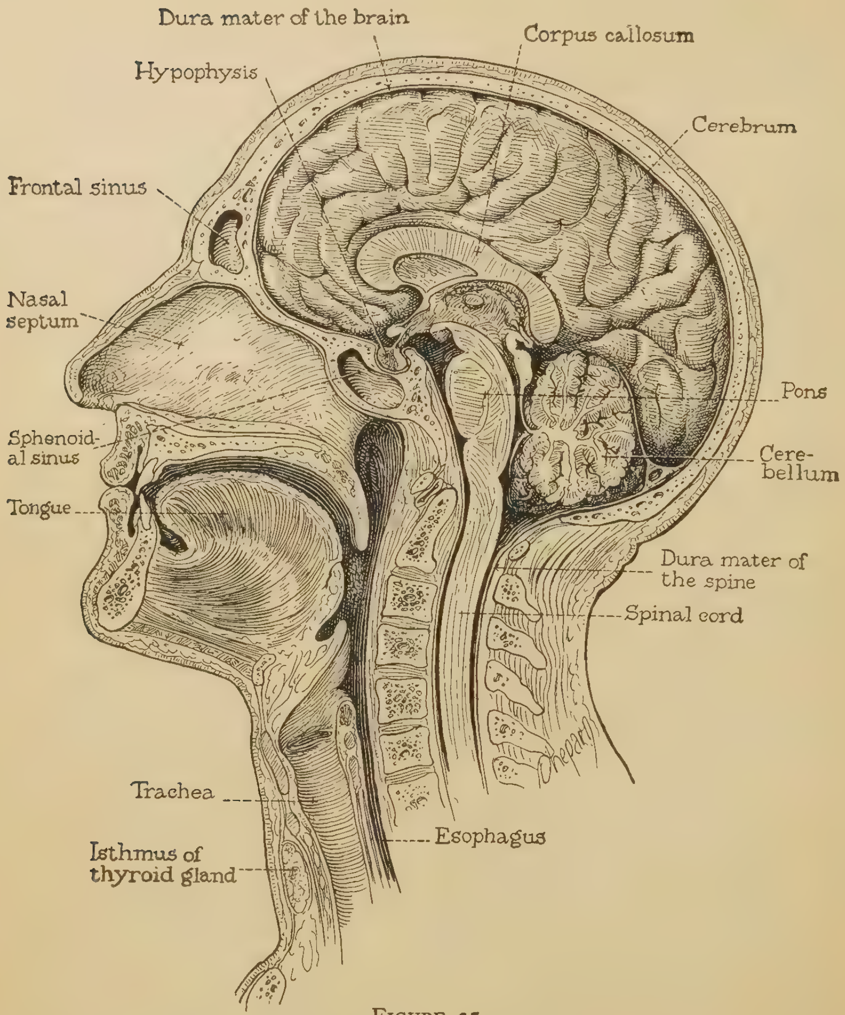

Dura mater of the brain
Corpus callosum
Hypophysis
Cerebrum
Frontal sinus
Nasal septum
Pons
Sphenoidal sinus
Cerebellum
Tongue
Dura mater of the spine
Spinal cord
Trachea
Esophagus
Isthmus of thyroid gland
Shepard

FIGURE 35

The upper respiratory system of an adult. As age advances the tonsils and adenoids unless infected, tend to atrophy. The frontal and sphenoidal sinuses drain into the nose. Note the thin layer of bone between the nose and the brain cavity. Meningitis can occur from nasal infection. Note in the posterior pharynx, where the adenoids are in the child, the opening of the Eustachian tube, which leads to the middle ear.

protect the middle ear by covering the pharyngeal end of the Eustachian tube; if they become infected, the infection frequently travels up the Eustachian tube, causing pus in the middle ear and later mastoid disease. An infected adenoid is the most frequent cause of mastoid disease in children.

DISEASES OF THE RESPIRATORY SYSTEM

The diseases of the respiratory system are in some ways rather peculiar to it, and dependent upon its anatomy and functions. The outstanding feature of its pathology is that it is subject to infections — bronchitis, tonsillitis, pneumonia, influenza, tuberculosis, etc. This is perfectly natural when we remember that the air is at all times full of bacteria, and that this bacteria-laden air is breathed into the lungs twenty times a minute all our lives. It is a matter of the most ordinary observation among medical men that epidemics of "colds," which, of course, are simply infections of the nose or bronchi, occur after a period of dry weather. This simply means that the sputum of infected individuals is cast out on the ground and dried, and its contained germs blown about. Colds, while they are strictly infections, are brought on by the accessory factors of chilling the surface of the body, and especially wetting and chilling the feet. Winternitz, a German hydrotherapist, has worked out a number of reactions of mass movement of the blood; for instance, cold applied to the feet causes blood to leave the brain; cold applied to the back causes blood to leave the nose by constricting the nasal blood-vessels. Here is the explanation of the old housewife's habit of putting a key to the back of the neck in nose-bleed. Cold on the surface of the body can change the amount of blood, say in the nose or lungs, at the very time when it is needed there to overcome the bacterial invasion. So that there is some scientific basis for the term "catching cold."

Another condition to which the lungs are peculiarly liable is the deposit of foreign substances floating in the blood-stream. These are known as emboli. The most frequent sort are small clots of blood which may form anywhere in the body at the site of disease. If a clot of blood is washed off into the blood-stream anywhere in the systemic circulation, it is unlikely to find lodgment until it gets to the lungs. The calibre of the blood-vessels it enters is bound to be successively larger until it reaches the right heart, but then it is shot into the lungs, and here begins to pass through blood-vessels whose calibre is successively smaller. Finally it reaches a twig so small that it cannot pass through, and sticks, occluding the vessel from that point on. Not only clots of blood, but little masses of pus, and tumour- or cancer-tissue, thus find lodgment in the lungs.

The two commonest diseases of the lungs are pneumonia and tuberculosis. Pneumonia may be of various kinds. It may be caused by any one of a dozen kinds of bacteria. The word "pneumonia" itself merely means an infection of the lungs. Certain germs, notably the pneumococcus, cause all the alveoli in one lobe to be filled up with an inflammatory exudate. This form is then called lobar pneumonia. At other times small deposits of infection at the end of bronchi all over both lungs occur — the condition known as broncho-pneumonia. The form which occurred in the recent great epidemic of influenza was of the latter type. Lobar pneumonia is likely to run a short, definite course and terminate suddenly — the crisis. The termination of broncho-pneumonia is less abrupt.

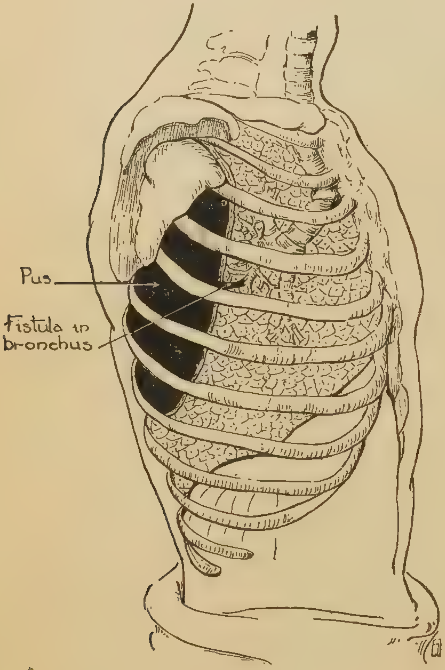


FIGURE 36

Pus in the chest cavity following pneumonia (empyema) and burrowing its way to the bronchus so that it was coughed up. The emaciation, fever, and expectoration simulated tuberculosis.

A frequent complication of pneumonia is a collection of pus between the two layers of the pleura — that is, between the lung and the chest wall. It is known as empyema. (All circumscribed collections of pus are named empyema — as empyema of the maxillary antrum in the nose, empyema of the gall-bladder. This is empyema of the pleural cavity. When the word "empyema" alone is used by physicians, it means pleural empyema.) It is due to the extension of the pneumococcic infection to the pleural surface. As the infection in the lungs subsides, the infection in the pleura causes the formation of pus. The condition is inevitable in a certain number of cases of pneumonia, and implies no lack of skill on the part of the attendant physician. The signs of the presence of the pus are the continuance of the fever, which after the establishment of the empyema is high only in the evening, and the continuance of the prostration and weakness of the original disease. The white cells in the blood are increased: i.e., there is a leucocytosis (q.v.). The condition may go undetected for long periods of time. Sometimes the pus burrows through the lung and is discharged from a bronchus as sputum. Surgical drainage is the only effective treatment known.

Treatment of either form of pneumonia is symptomatic and expectant. In other words, we have no serum, no specific, to introduce into the body to combat the toxins of the disease or kill the germ. There are many alleged serums to be obtained and much work is being done on the subject in laboratories all over the world, but at present no specific serum or antitoxin has been demonstrated beyond peradventure to be useful. Under these circumstances we must let nature do the best she can. If not hampered too much, she will usually do perfectly. Absolute rest, freedom from fussy meddling, such as turning the patient, examining the patient, treating the patient every hour or so, seems the most important measure of all to institute. Fresh air is important. Some twenty-five years ago, when Dr. Northrup began to put his children with pneumonia on the roof of the Presbyterian Hospital in New York, people threw up their hands in horror. Putting sick babies with their lungs all inflamed right outdoors in zero weather, or even with the snow coming down! It was dreadful. But, curiously enough, the babies did better on the roof than in a stuffy room. "Why make your pneumonia patients take five breaths when three will do the work?" Dr. Northrup asked, and up to the present echo alone has answered: "Why?"

The conquest of tuberculosis, one of the outstanding features of modern civilization, has probably been brought about by factors which the medical profession cannot take entire credit for. Tuberculosis is a disease especially of poverty (though it occasionally spreads from the poor to the well-to-do or the rich): a disease of overcrowding, of insufficient food. In the past seventy-five years such conditions have been notably ameliorated. I am inclined to believe from my examination of the matter that the carefully organized systematic distribution of the world's food-supply has been the most potent single factor in the world-wide reduction of the death-rate from tuberculosis. There is no doubt that such a decline has been going on steadily for at least seventy-five years and possibly more. The beginning of this period of decline, of course, antedates the discovery of the tubercle bacillus and of the intensive campaign for prevention of tuberculosis carried on by the medical profession.

What the profession can take credit for is the systematic organization of the whole world for the detection of cases of tuberculosis in their incipiency and for the establishment of means to treat and cure them. The great gospel the profession has preached, and, a curious exception to preachings generally, has practised, is the early diagnosis of tuberculosis of the lungs. Only in that way can permanent cure be successfully established. Cure in relation to the stage of the disease is shown in the following set of figures, which were amalgamated from the statistics of a number of sanatoria and are therefore free from bias:

PERCENTAGE OF CURES OF TUBERCULOSIS

(After 5 years)

	Cured	*Arrested*	*Improved*	*Unimproved*	*Died*
Incipient	86%	13%	1%	None	None
Moderately advanced	54%	26%	9.5%	6.5%	4%
Far advanced	17%	31.5%	19%	27.5%	5%

Therefore the profession has tried to set up an idea of tuberculosis entirely different from the classical old picture of "The Consumptive" — the portrait of a pale, bony, haggard ghost with a red spot in each cheek, racked by coughing, with flecks of blood upon his lips after expectoration. That is the old case. That is the case which has had the disease for years before such a picture developed.

The tubercle bacillus when it invades any part of the body for which it has an affinity — and those parts are, in the order of frequency, the lungs, the bones and joints, the lymphatic glands, the kidneys, and the meninges at the base of the brain — produces a certain characteristic reaction on the part of the tissues. This reaction is of a defensive nature, designed to engulf and destroy the tubercle bacillus. It results in a tissue change which has been called from time immemorial *the tubercle*, and indeed it is that which has given the disease and the bacillus their names. It can be seen with the naked eye as a small whitish spot in the infected tissue. Under the microscope it is found to be a large central cell, formed from a coalescence of cells, surrounded by a ring of phagocytes. The large cell has engulfed the tubercle bacillus and is trying to strangle it to death. Usually it succeeds.

Everyone gets tuberculosis at some time or other. Nine out of every ten human beings have had a tuberculous infection and have killed off the invader. Sometimes the bacillus gets the best of things, and the tissue begins to break down and liquefy — necrosis. In the lungs when this stage has been reached, secondary infection practically always takes place — other germs constantly going in and out from the lungs light on this soft spot and cause further destruction. The object of the alert diagnostician is to detect the disease before it reaches the stage of secondary infection.

William Osler illustrated, beautifully, the process of universal infection with tuberculosis, explaining why certain individuals recover and why others succumb to the disease, by likening it to the parable of the sower. The sower, you remember, went forth to sow and some of his seed fell upon stony ground, some was picked up by the birds of the air, some fell among tares, which sprang up and choked it, and some fell upon good ground and brought forth a thousandfold. Most of us, so far as the tubercle bacillus, as well as the kingdom of heaven, is concerned, are stony ground: it finds no lodgment. For some the blood-cells play the part of the birds of the air and carry the bacilli away. For some the defensive reactions of the body, like the tares, choke the germ's growth. But in a few the bacilli find favourable conditions and bring forth fruit a thousandfold.

How do we detect the early cases? The patient himself has to help a good deal. The earliest symptoms of tuberculosis should be known to everyone — certainly to the head of every family. We go back to Huxley's image of the chess player here. Isn't it curious that a man will stuff his brain with all sorts of perfectly useless information — the date Columbus discovered America, the outcome of Corbett's fight with Sullivan, the final lines of Bryant's "Thanatopsis" — and be shut off from information which might save his son, his daughter, his wife, or himself? There appeared some years ago an article in the *Atlantic Monthly* entitled "The Confessions of a T. B." I should like to see it reprinted. It was written, I believe, by a professor of history in an American university and is thus the notation of an intelligent observer. It records the author's experiences as his own case of tuberculosis developed. One feature will always stay in my memory. His very earliest symptom was an intolerable fatigue. It was not just the fatigue of nervousness or of exertion. It was like a physi-

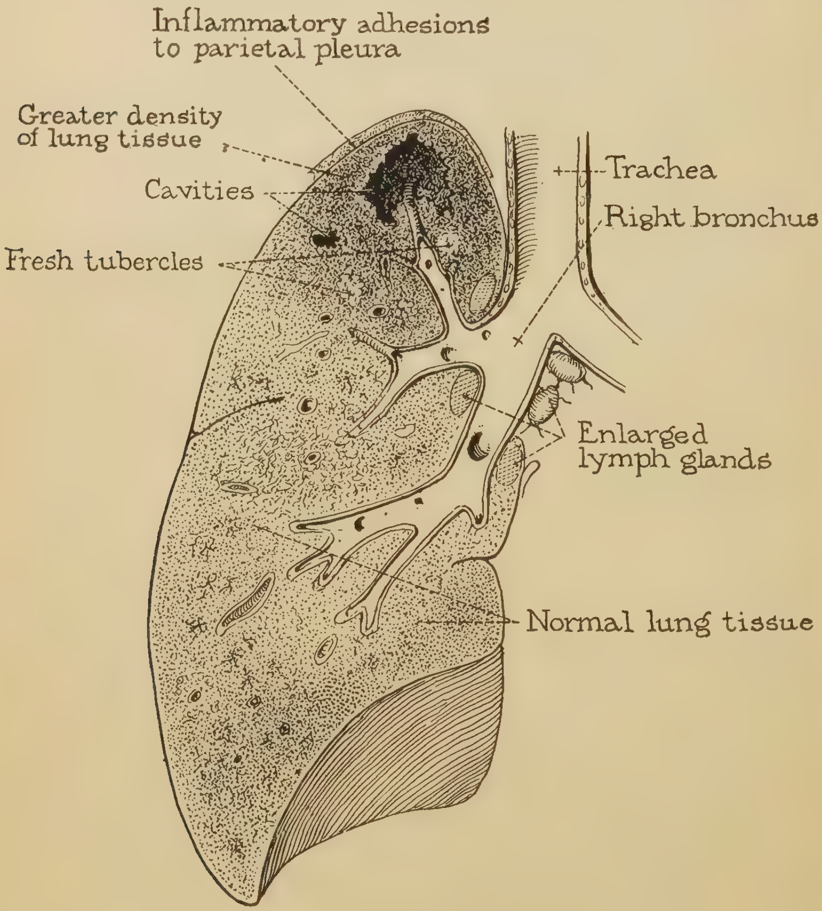

Inflammatory adhesions to parietal pleura
Greater density of lung tissue
Cavities
Fresh tubercles
Trachea
Right bronchus
Enlarged lymph glands
Normal lung tissue

FIGURE 37

Tuberculosis of the lung. The usual situation in the apex or top of the lung is represented. Various stages of the disease are seen — enlarged lymph glands, tubercles without tissue breakdown, and finally cavity formation.

cal load, even when he had done no work at all. He stated that he used to throw himself on his bed in the afternoon, every muscle-fibre in his body individually crying out its weariness. That is one early symptom I have traced over and over again in patients. Cough may come much later. Expectoration still later. An unexplained steady loss of weight in a young person always needs investigation.

Hæmorrhage consists in the sudden appearance of a cupful of blood in the mouth. The one who has a hæmorrhage from the lungs is lucky. Lucky because he is shocked and frightened into knowing something is the matter — not, like the others, allowing symptoms to creep on day after day until it is too late. Keats, you remember, had a hæmorrhage while getting into bed one night. "Bring me a candle," he cried. "Let me see that stain." And when he got it — "It is arterial blood. That is my death-warrant." It would not have been now.

Perhaps the most important piece of evidence is the record of the bodily temperature four times a day — at 8 A.M., 12 noon, 4 P.M., and 8 P.M. In early tuberculosis it is low or subnormal in the morning, rising daily from 99° to 100° in the afternoon and beginning to sink back again at night. Later in the course of the disease this diurnal fluctuation is accentuated. The diagnostician consulted must make a careful examination of the bared chest — the most important single part of the examination — and examine the sputum and the X-ray of the chest.

Treatment requires even better information and judgment than diagnosis. The first thought of the patient and the family is a suitable climate. The decision finally to be made on this point is purely one of economics. The essential thing is not climate: climate is a frill. If the patient can afford to go to a climate and have the essentials besides, all well and good, but to sacrifice the essentials for climate is to make a mistake. I have, in another place, set down in parallel columns the average layman's and the well-informed physician's idea of the most important things in the treatment of tuberculosis. It may be well to repeat them here. Their relative emphasis in the two minds has been indicated by the help of typography:

THE TREATMENT OF TUBERCULOSIS

Layman's Idea	*Physician's Idea*
CLIMATE	**REST**
SERUM (preferably from a turtle)	**FRESH AIR**
HORSEBACK RIDING	**EXTRA FOOD**
A DRUG WITH GOLD IN IT	**SURGERY**
MILK AND CREAM	**MENTAL ENCOURAGEMENT**
	CLIMATE

This is not intended to be a detailed technical account of the treatment of tuberculosis for the guidance of a patient, so I will let it go at that, but I cannot refrain from calling attention to the remarkable development and success of the surgery of tuberculosis in the past decade. Tuberculosis, or indeed any procedure within the chest, was not a subject which attracted the attention of surgeons during the early period of surgical advance following the period of Lister. Not until approximately 1910 was there any considerable widespread experimentation with definite procedures. Now there have been developed a dozen surgical operations, most of them applicable to somewhat advanced cases, which have made such cases far more hopeful than formerly. The general principle of all these is the same — viz., to collapse and put out of commission the affected lung. They are therefore particularly applicable to tuberculosis confined to one lung, or predominant in one lung. The most usually used is that called artificial pneumothorax, in which a gas is pumped into the pleural cavity, collapsing the lung on that side. Other procedures are to cut the phrenic nerve on one side; this nerve supplies the diaphragm and severing it would mean that the diaphragm on that side would be paralysed and remain stationary so that the lung would not move during respiration. Another procedure is the cutting away of all the ribs on one side, allowing a complete collapse. All of these methods have resulted in remarkable examples of recovery — though they are last-resort surgery to some extent.

The story of the use of fresh air as a treatment for tuberculosis does not carry very far back. George Boddington of Sutton-Coldfield published an article on the subject in 1845. In the preface to *The Doctor's Dilemma* Shaw mentions this and states that so revolutionary was the idea of putting tuberculosis patients outdoors that Boddington was disgraced and driven out of his practice. I can find no record of it, but I have long since discovered that, though in this case he furnishes no reference, Mr. Shaw knows everything. I have read the essay Boddington wrote. One sentence conveys the whole theme — "Fresh, cold air is the best stimulant to the healing powers of the lungs." He tells of the practice then prevalent of shutting consumptives up in an air-tight room, as if air would kill them, and of the surprise (I think we may translate *horror*) shown at his treatment of one young lady, whom he ordered to drive in a pony-cart every day, winter and summer, rain and snow. I can see the glances of disapproval which glinted out from behind Victorian window-curtains as she passed — the poor wounded dear exposed to the inclemencies of an English spring. But she got well, so honest George Boddington says. Stubborn George Boddington would be a better name for him. It is well for many people he was so stubborn.

Our MEANS FOR THE EXAMINATION OF THE LUNGS in order to determine the presence and nature of disease are now quite complete. They began, curiously enough, in the courtyard of an inn in Gratz in lower Austria, about the middle of the eighteenth century. We even know the name of the inn: "at the sign of the Black Moorish Woman" (*Züm Swartzen Möhren*). The innkeeper's name was Auenbrugger, and on November 19, 1722, he had born to him a son, christened Leopold. The boy, as he grew up, naturally assisted in the duties of the inn. As those were not the days of the enlightenment, the father sold wine. The wine was kept in wooden casks and it was a matter of economic importance to know how much wine was left in a given cask. The cask being made of wood, no one could see through it. But young Auenbrugger learned from his father a simple rough method of determination. The cask would be set on end and a series of slaps with the open hand given it, beginning at the top and going downward. At the top, where there was no wine but only air, the note was low; over the wine the slap of the hand suddenly evoked a high-pitched note. Very simple. As time went on, young Auenbrugger desired to study medicine, and matriculated at the University of Vienna. In practice he made quite a success. His biographer records that he was appointed accoucheur to a duchess. Think of that, Hedda. I can see him now entering humbly and respectfully into the lying-in chamber where the young duchess was writhing and cursing at him from the bed. He who was the most important man in Austria in that century! He appears to have been quite dextrous. He saved not only the duchess but the young princeling. That valuable existence was preserved so that its owner could later in life haunt the stage-door of the Opera House in Vienna and become maudlin over his burgundy as he caromed about amidst the gilded chairs and mirrors of the great *salon* of the palace. Other duchesses employed him, and even a margravine. Finally he was made court physician to Maria Theresa herself. With what unction he must have announced the tremendous fact to the little *Hausfrau* — he who had more ideas in his solid head than all the Hapsburgs who ever lived. He even wrote an operetta, *The Chimmey-sweep*, which was performed at court. How proud the proprietor of the *Gasthaus* at Gratz would have been if he could have heard that!

One day a patient of Auenbrugger's died, and, as autopsies were becoming popular, he opened the body. The chest was full of fluid — of pus. He had never understood the patient's illness during life. Why had he not suspected there was fluid in the chest? he wondered to himself. Would there be any way of finding out if fluid was in a chest during life? He remembered his father slapping wine-casks. The chest with fluid in it was much like a wine-cask. It had a rigid opaque wall; there was air above and fluid below. He would try it. He took patients and began slapping their chests. The thing worked perfectly. He could find fluid and also the solidifications of tuberculosis and pneumonia. He called the method *percussion*. In 1761 he published his account of it, the *Inventum Novum* or *New Invention*. Percussion, of course, is still used — one of the staple methods of examination.

No one up to that time had ever thought of *listening* to the sounds made by the air going in and out of the lungs — nor to the sounds made by the heart as the blood was pumped round. This was reserved for another and later fortunate accident.

About 1814 a French physician was strolling near the Necker Hospital in Paris. Though he was a thin, ascetic-looking man, he did an enormous amount of work and was one of the most fashionable and busiest practitioners in the capital. His name was René Théophile Hyacinthe Laennec. He was a Breton. The hospitals

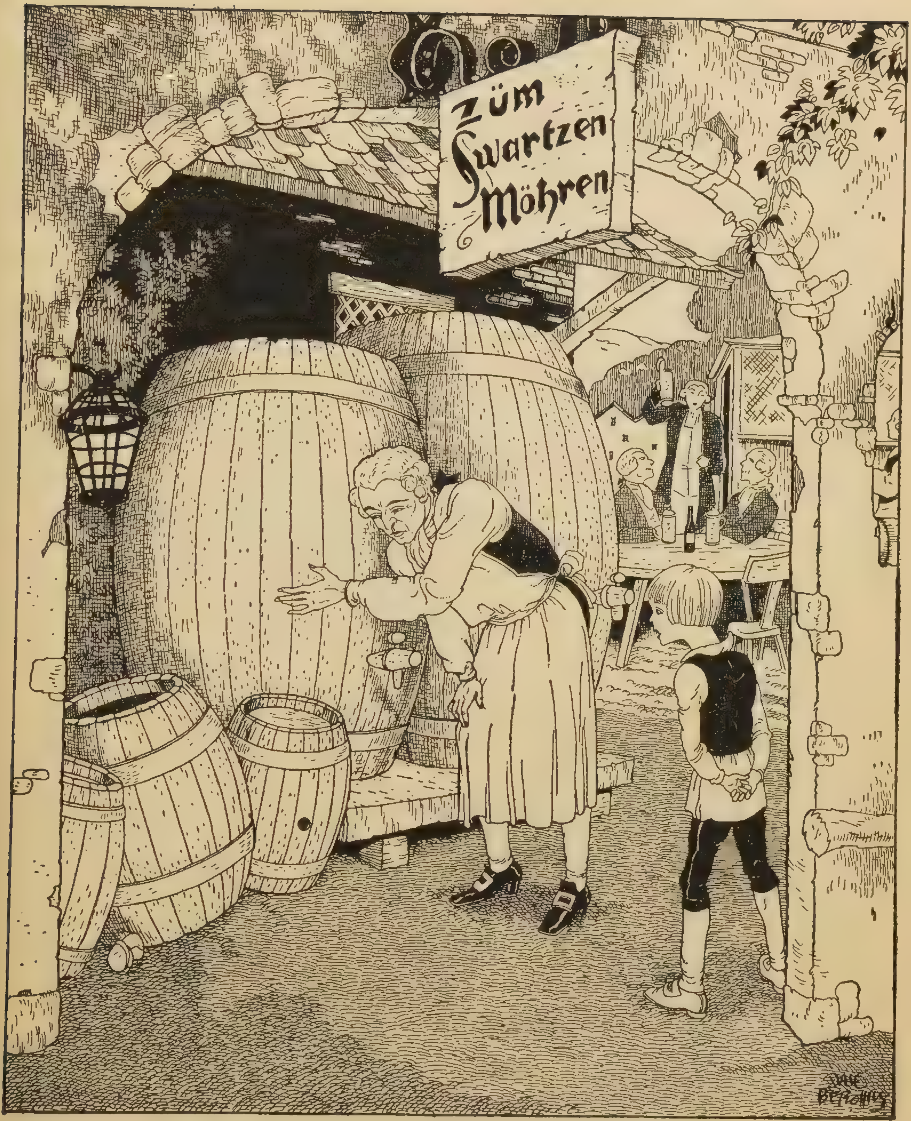

Zum
Swartzen
Möhren

FIGURE 38

The birth of percussion.

were full of the soldiers of the Grand Army. Many of them were dying of tuberculosis. Laennec possibly was wondering if, by making a diagnosis of that disease earlier, treatment might not be improved. His attention was directed to some children playing on a seesaw. For the moment they were not seesawing, but had adapted the seesaw to another game. One had placed his ear close to the board at one end, another at the extreme other end scratched with a pin. They had made up a code, and scratched messages to each other without speaking. Would it be possible, thought Laennec, to hear sounds inside the chest by using a wooden tube or cylinder? He tried it. There were sounds. What did they mean? He recorded them faithfully and followed the bodies to the autopsy table that he might find what the sounds signified. In 1819 he published his book *On Auscultation*. The stethoscope was born. If you will go to Quimper in Brittany, you will find a statue of Laennec in the market-place. Take your hat off before it. He was one of the greatest of the sons of men.

Important information about the state of the lungs is also obtainable by the examination of the secretion, or sputum, which is cast off by the lungs in disease. This secretion may be the drainage or pus from infected areas, or it may be the secretion poured out from the glands in the bronchi as a result of irritation. In the first instance the most important information we can get is the determination of the exact germ causing the disturbance. This is especially necessary if the question of tuberculosis is raised. The technique of recognizing tuberculosis bacilli was made very easy by the researches of Robert Koch. You will find his story told much more extensively than I have space for here in Paul de Kruif's *Microbe Hunters*. The picture of the man as he emerges in that interesting narrative is one of the most fascinating human studies imaginable. Though he was married to a hard-headed, practical woman who wanted him to succeed as a general practitioner, his eyes suddenly became filled with the glory of a great light. He was hag-ridden with his desire to find the germs which the Frenchman Pasteur said caused all diseases. His wife, like most women, and, to be perfectly just, like most men, was impatient of anyone who saw visions. She did not understand why he did not want to go out and attend confinement cases and broken legs and gather shekels together and provide for their

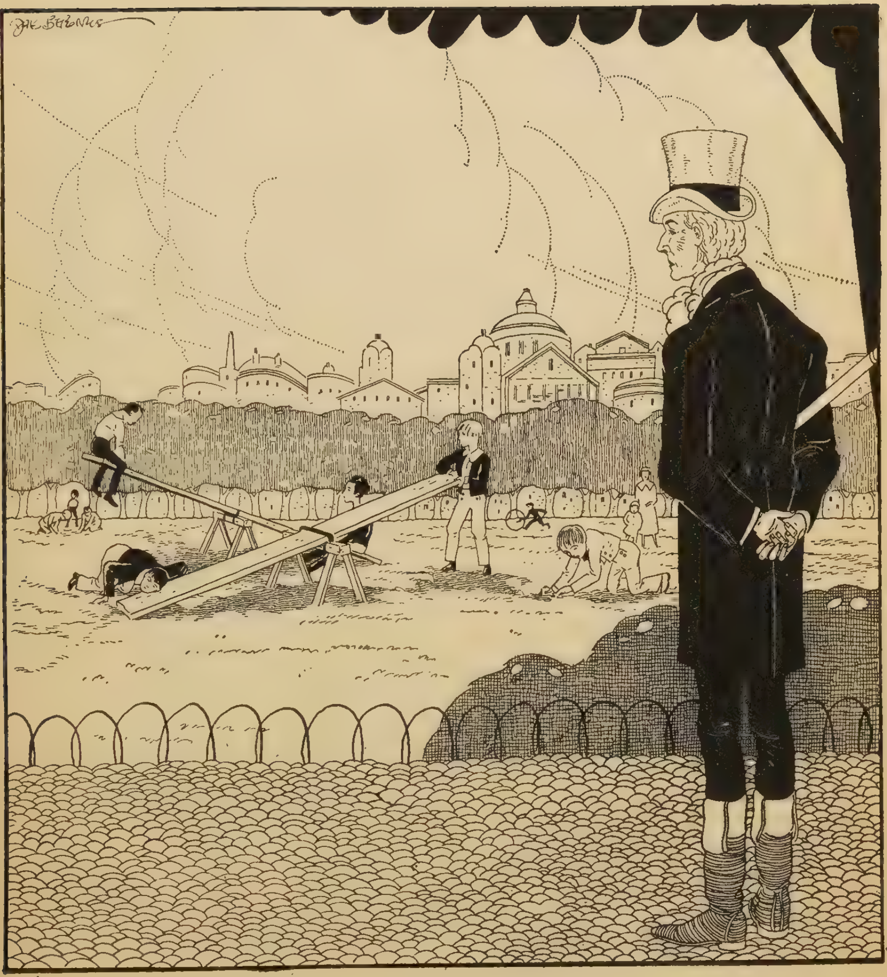


FIGURE 39

The birth of the stethoscope.

old age. What was this light in his eyes which drove him to sit staring into space or restlessly tinkering with glass tubes and pipettes and his microscope, and his bottles of stains? His life was as much a triumph over her and her common sense as it was a triumph over disease. His first great discovery was the cause of wound infection. Later, when he was famous and established, he discovered the tubercle bacillus. He showed how to stain it so that it is instantly recognizable under the microscope. The secret consisted in the fact that it is what is known as acid-fast. If you stain most bacteria and then run acid over them, the acid will dissolve out the stain. But not so the tubercle bacillus. So Koch hit upon the idea of smearing sputum on a glass slide and staining it first with a red stain. Then he ran acid over the slide. This dissolved out all the red stain from everything but the tubercle bacillus. Then he stained the slide again with blue stain. Under the microscope all the cells and incidental bacteria were stained blue, while the tubercle bacilli were red. We still use his method.

The last of the great means of examination of the lungs came with the development of the X-ray. When it first began to be applied to diagnosis, it was thought that it would be useful only for the hard parts of the body — for bones and joints and their injuries and diseases. But soon, with the improvement of tubes and apparatus, it was discovered that changes in the soft tissues of the lung (and heart, for that matter) could be seen with the X-ray. The changes of tuberculosis, pneumonia, of fluid and pus in the chest, are seen perfectly. It furnishes us the most serviceable confirmation of the findings of percussion and auscultation (or listening to the lungs) in health and disease.

CHAPTER V

THE BLOOD AND LYMPHATIC SYSTEM

The blood is a tissue. Like all tissues it consists of cells placed in an amorphous intracellular stroma. On account of the peculiar functions of the blood — to be a messenger and mediator between all parts of the body — it must be able to move; so its stroma, the blood-serum, is fluid, whereas the stroma of every other tissue is solid. Another peculiarity the blood has as a tissue — its most numerous and important cells, the red cells, are without nuclei. Still another necessary feature of the blood is its ability to solidify, or, as we say technically, coagulate, when it reaches air. If it did not have this feature, the smallest cut in a blood-vessel would shortly drain every drop of blood from the body.

The cells of the blood are of two classes. The most numerous, as I have just said, are the red cells. These are wheel-shaped with an indentation in the centre. They are made up in chemical composition largely of iron in the form of hæmoglobin. They carry oxygen from the lungs to the tissues, and carbon dioxide from the tissues to the lungs.

The white cells of the blood are of various kinds, differing quite distinctly in appearance. It will do no particular good, so far as I can see, to enumerate here the various kinds of white cells. Their names must appear quite formidable to a lay reader — (1) polymorphonuclear neutrophile leucocytes, (2) lymphocytes, (3) basophilic leucocytes, (4) eosinophilic leucocytes, etc. Their functions appear to be protective and healing. Metchnikoff called the polymorphonuclear leucocytes the phagocytes because they concentrated at any point in the body where infection was present and swallowed or engulfed the invading germs. The number of them which is actually in the blood under normal circumstances is small compared with their number at the time of infection, when they greatly increase. Inasmuch as we can count them quite accurately, this fact is taken advantage of for purposes of diagnosis in obscure inner infections such as appendicitis and pneumonia. Another function of the white cells is the healing of wounds. This appears largely to devolve upon a type of cell called the mononuclear, though all the others have some share in it.

One other body of a sort seen nowhere else occurs in the blood. It is called the blood-platelet. Histologists have been completely baffled in attempting to classify it, as it is not a cell. It looks more like a disembodied nucleus than anything else. Its function is also debatable. The best guess on the subject seems to be that it is concerned in the act of coagulation — that it dissolves upon being exposed to the air, liberating the fibrin-forming elements thromboplastin, necessary for coagulation. At any rate, we know that in such blood diseases as purpura, when the coagulating power of the blood is greatly reduced, the blood-platelets are conspicuously absent from the blood.

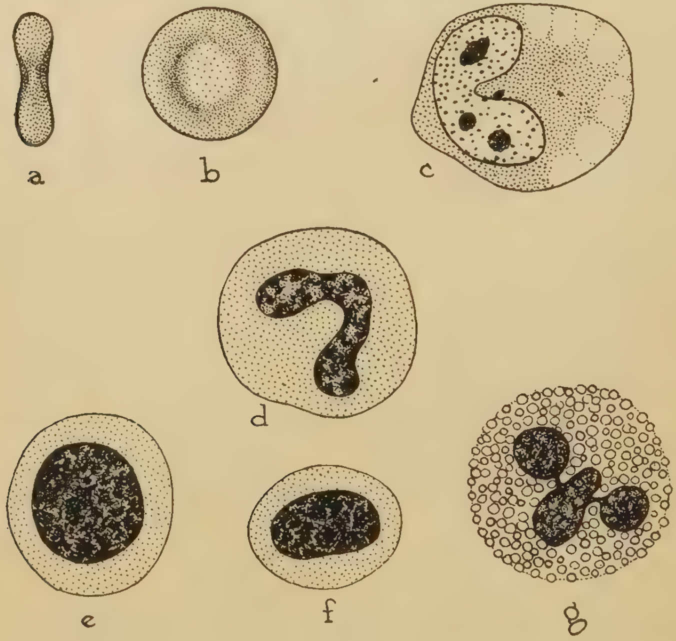


Figure 40

Types of blood-cells. a, b — red cells, seen sidewise (a) and flat (b). c — an endothelial cell. d — a leucocyte (polymorphonuclear neutrophile), the most numerous type of white blood-cell. e and f — large and small lymphocytes. g — an eosinophile leucocyte.

The act of coagulation itself is one of great interest. Its biologic purpose is quite plain — to prevent all the blood from oozing out of the body through one aperture if a blood-vessel is severed. When an opening is made in a blood-vessel, the blood forms into a firm clot or cork covering the opening in the vessel and preventing the escape of any blood behind it. The function of coagulation has been developed during the process of evolution, because any animal whose blood does not have that property is sure to die off before it can have progeny.

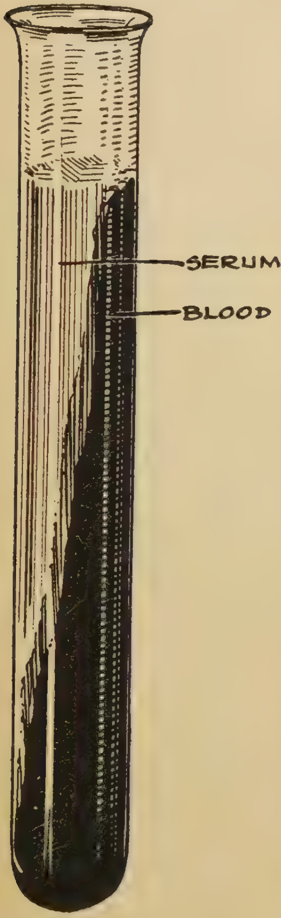


FIGURE 41
A blood clot.

The phenomena of coagulation or clotting have received great attention from physiologists since the earliest times. The gross facts are that if you remove a tablespoonful of blood from a vein and allow it to stand in a clean test-tube for a few minutes, it will form a solid jelly-like mass which sticks to the sides of the tube; it will not spill if the tube is inverted. If allowed to remain half an hour, a portion containing all the cells will contract down, squeezing a clear fluid from it, so that the tube now looks as if a central cord of red jelly were suspended in a clear yellowish fluid. The central mass contains all the blood-cells stuck together and enmeshed in some strands of a gelatinous material called fibrin. The important and as yet unknown fact about coagulation is the mode of formation of the fibrin. Fibrin does not exist as such in the blood, but a substance, fibrinogen, which is formed by the liver does so exist and this, when acted upon by another substance, thrombin, forms fibrin. Thrombin itself does not exist in the blood, but is formed by the action of several substances. One of these is calcium, one is a substance we may call thromboplastin, which probably is formed by the blood-platelets' dissolving. In other words to recapitulate the process of coagulation, the blood-platelets first dissolve, liberating thromboplastin; this unites with calcium to form thrombin; thrombin acts on fibrinogen to form fibrin; fibrin is the clot. The process is complicated, and is discussed in more detail in larger works on physiology. (See Howell's *Text-book of Physiology.*)

There are certain very interesting and unusual diseases which result from the inability of the blood to clot. One of these is called hæmophilia. It is strictly hereditary and like many hereditary diseases is transmitted in a certain line. It always skips a generation and occurs only in males. But males never transmit it. It is transmitted in the female line. In other words, mothers transmit it only to sons. The recipient of it is likely to bleed profusely at the slightest injury, the hæmorrhage going into the internal tissues, usually joints. I had one patient, a boy who drove a butcher's wagon, and the jar he received in jumping down from the wagon started so many hæmorrhages into his joints, before he knew what was the matter with him, that he was crippled for life. It is the usual fate of these individuals. We have no insight into what substance in the blood is lacking in hæmophilia.

In purpura, a similar condition in some ways, the number of blood-platelets is decreased. This we can treat by transfusion, injecting the blood of another individual into the patient. Surgeons use various substances to stop hæmorrhages which they cannot control otherwise — calcium, horse-serum, and artificial thromboplastin.

The formation and destruction of blood-cells do not take place in the blood-stream. The red cells, being without nuclei, cannot divide and increase, and the white cells do not, probably because they are too adult. The site and method of blood formation and destruction have engaged the attention of a great many workers. The consensus of opinion is that the red cells are formed in the bone marrow. There is no consensus of opinion as to where the white cells are formed. Two views exist: one, the unitarian view, that they are all formed in the bone marrow from a certain single type of cell; the other, that some are formed in the marrow, some in the lymph glands, and some in the lining of the smaller arteries. Where the blood-cells go when they die is a matter that is also far from any satisfactory solution. Whether they go to one place if they have been good little red cells, and another place if they have been bad little red cells, I do not know. The spleen seems to be the most likely place for them all, according to the evidence, and they (or their colouring matter) are thence conveyed to the liver to be turned into bile. There are, however, a number of spleens of small size, the hæmolymph nodes, scattered through the body, so that removal of the spleen does not result in death. We know certainly that in many diseases of the blood — myelogenous leukæmia, splenic anæmia, etc. — the spleen is enlarged. In certain peculiar anæmias where blood destruction is going forward at a rapid rate, removal of the spleen effects a cure.

The blood contains, of course, a large number of salts and chemical substances. These are largely in the serum and are being continuously transported over the body to the places where they are needed. They consist of water, chloride, phosphate and sulphate salts, fats, glucose, nitrogenous substances such as urea, uric acid, creatinine, and amino-acids. Some of these are going to the kidneys or lungs to be excreted, some of them are going to the tissues to be burned or built into new tissue.

The blood, however, is not the only fluid transporting material to different parts of the body. The lymph, which is merely a form of blood-serum and is derived from it, bathes all the bodily tissues. Along the course of the lymph-stream are small seed-like enlargements, the lymph nodes. They take an active part in the destruction of infection around a given part, and are always found enlarged in the region of an infection. For instance, a particularly rich supply of them exists in the neck and under the jaw. If there is an infection of the tonsils or an abscess in the teeth, these neck or jaw glands enlarge. Other nests of them occur under the armpits and in the groin. The neck glands are particularly liable to tuberculosis, which special condition was once called scrofula, or the king's evil. It was the last disease, so far as I know, which was generally believed to vanish at the touch of a royal hand. In England up to the time of the early Hanoverians regular days were appointed for the king to "touch" for the king's evil, and long lines of subjects would wait pathetically for the laying on of the princely palms.

DISEASES OF THE BLOOD

The blood is affected in many strange ways. Some of the most bizarre of all diseases are classified under the heading of diseases of the blood. The simplest of all is an anæmia from hæmorrhage. The hæmorrhage results in a simple reduction of the amount of the mass of blood. The entire amount of blood in the body is about five per cent of the individual's weight. About a half to a third of this may be lost without particularly serious results. The body is able to replace this loss, the time taken for regeneration being from a month to six weeks. Slow, repeated small hæmorrhages may cause a secondary anæmia quite as readily as a single large hæmorrhage.

In most of the blood diseases it is the bone marrow that is affected, the circulating blood-cells simply showing the reaction of this marrow change. Some of the diseases — the leukæmias — appear to be neoplastic or cancerous conditions of the marrow, throwing out enormous numbers of immature and partially developed white cells. In pernicious anæmia there is an appearance as if the marrow were affected with some powerful poison, deadening all of its activities. The red cells sent out into the blood-stream in pernicious anæmia are some of them young and immature and still have, like the primitive marrow-cells, nuclei. Others are large, and some small and fragmented. Pernicious anæmia, however, is a disease of the entire body, other structures such as the stomach, the tongue, and the central nervous system being affected.

The hæmorrhagic diseases of the blood have already been described. A group of anæmias in which the spleen is enlarged, called the splenic anæmias, probably depend upon an overactivity of the spleen's function of destroying red blood-cells.

In the treatment of blood diseases, various means are at command. If the marrow is exerting an increased activity, as in the leukæmias, the X-ray applied over the long bones which contain the marrow will for a time reduce its hyper-activities. If the spleen is destroying too much blood, it can be removed surgically. If hæmorrhage or poisoning has reduced the entire amount of blood, this can be replaced by transfusion — i.e., the addition of a volume of blood from a healthy person into the patient's blood stream. In pernicious anæmia various measures have been tried

— the use of hydrochloric acid to replace the deficiency in the stomach, arsenic to stimulate the bone marrow, transfusion to replace the loss of blood. Recently a diet rich in certain meat products, such as liver and kidney, has been so successful as to make us believe that perhaps pernicious anæmia is a food-deficiency disease, arising from the prolonged abstinence from a meat diet. Pernicious anæmia, however, has its ups and downs — relapses and remissions. Sometimes the patients will go along in apparent perfect health for years — seventeen years in one case recorded.

Our METHODS FOR EXAMINING THE BLOOD are quite complete. We can *count* the number of red cells and of white cells in a sample and make from this deductions as to the condition of the entire mass. The method of counting is really quite simple. Very accurately made slides to fit under a microscope are constructed and a central place etched off into squares. This central place or glass disk is now sunk down into the slide a very accurately measured distance, so that, if a drop of blood be placed upon it and covered with a delicate square of glass, one can see, looking down on the ruled space, the number of cells in a given area; one knows also what the depth of that area is. The diagnostician therefore, in making a blood count, counts a cubical amount of blood. In ordinary blood, however, the cells are so numerous that it would lead to inaccuracies to try to count them, so a dilution is made, with salt-solution for the red cells, with weak acetic acid for the white cells, because acetic acid dissolves all the red cells, leaving only the white to be counted. After counting the diluted blood in the accurately measured chamber a simple arithmetical calculation gives the actual number in a given area. The area used as a standard is a cubic millimetre. In this there are in health about 6,000,000 red cells and 5,000 white cells.

The blood count is useful, not only for actual diseases of the blood, but as an index of the general condition of the body. As has been intimated above, the white cells are counted for diagnostic purposes in acute infections. The number of white cells is an indication not only of the fact of infection, but also of the body's resistance to the infection. In appendicitis the white cells may be as high as 30,000 per cubic millimetre and are usually round 20,000. Increase in the white cells in infection is known as leucocytosis.

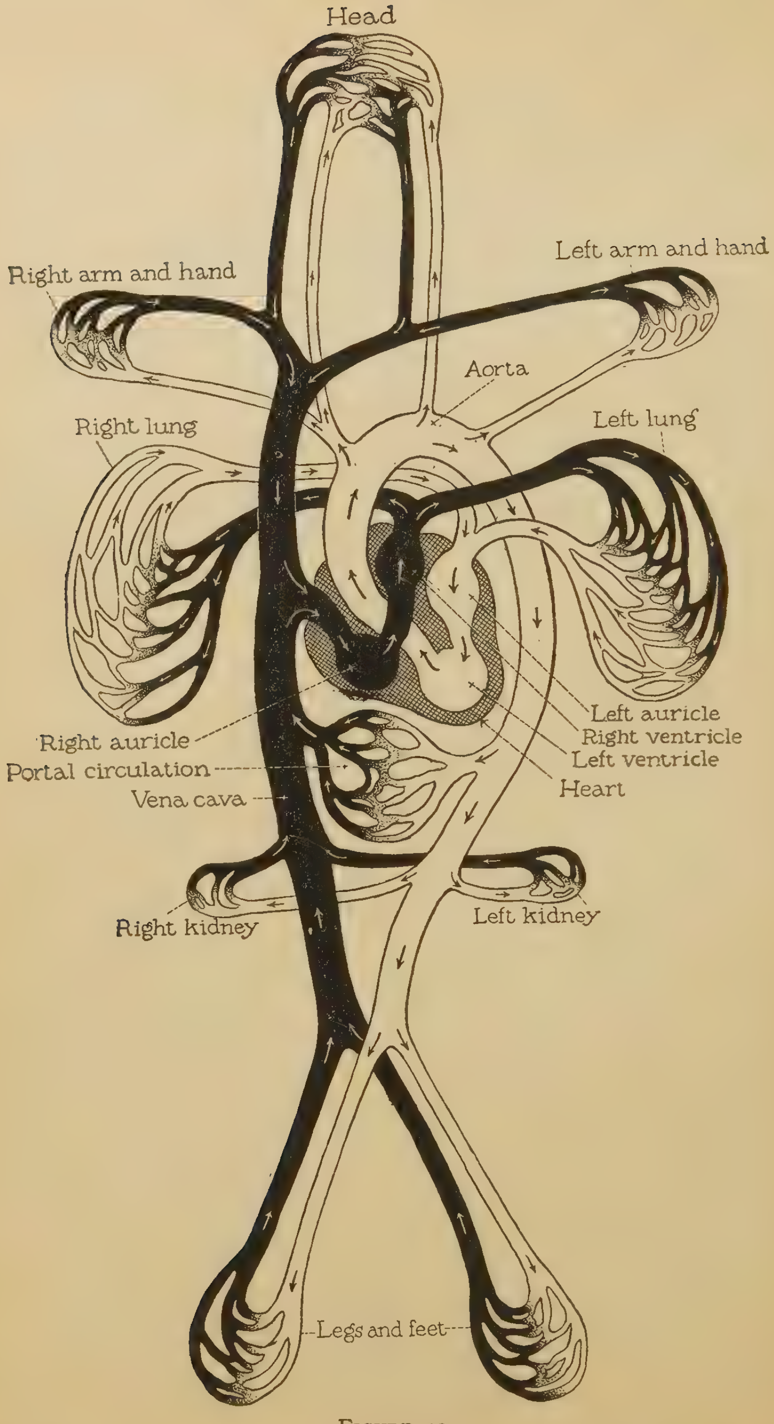

Head
Right arm and hand
Left arm and hand
Aorta
Right lung
Left lung
Left auricle
Right ventricle
Left ventricle
Heart
Right auricle
Portal circulation
Vena cava
Right kidney
Left kidney
Legs and feet

FIGURE 42

The heart and blood-vessel system. The diagram shows the cycle from right heart through the lungs, to the left heart, then through the system back to the right heart. Note that all the blood from the digestive system goes through the portal veins; i.e., through the liver.

CHAPTER VI

THE CIRCULATORY SYSTEM

The natural philosophers, as they were accustomed to call themselves, or, as we should call them, the scientists of the old Greek world, and of the Græco-Roman world, were very forcibly impressed with those constant and involuntary movements of the living body which partly they could see in other, and partly they could feel in their own persons. The motion of the chest in respiration, which they were never tired of calling bellows-like; the beating of the heart and of the pulse, which they were curiously blind in not associating with each other; the fact that if the smooth integrity of the skin were broken or cut, blood oozed or flowed out as if the skin were filled with a juice, were some of these. There were sensations in the abdomen too which they could feel in themselves though they could not see anything on the outside, which they knew must be due to movements of some organ: the gripings and cramps of the intestines, the sensation of hunger, and the certain knowledge that when food and drink was swallowed, it went from the mouth past the chest, into the abdomen below. They saw too that after food and drink were taken in, they were ejected from the abdomen, though as obviously changed and degenerated forms of whatever had been eaten and whatever had been drunk — the urine and the fæces.

These objective and certain facts demanded an explanation. The only resource open to the old natural philosophers was the dissection of dead animal bodies. They could not examine dead human bodies on account of religious and social scruples and prejudices. And they had no means of keeping an animal alive under dissection in order to watch the organs actually at work; in other words there was no such science as that of experimental physiology. Looking at the dead organs which had once been so filled with movement, they tried to deduce the manner in which they functioned; and some of their deductions were curiously misguided.

Of all these movements those of the lungs and heart, and the relation these had to the blood, interested them the most. It was easy to see that the chest was separated off from the abdomen by the diaphragm, and that the air which went in and out passed into the lungs; the heart was always found strongly attached to the lungs (by the pulmonary artery) and — not knowing that there was any change in the chemistry of the air which was exhaled as compared to the air which was inhaled — they assumed that the function of the lungs was to cool, fan-like, the over-heated blood. Blood was always found in the veins and the right heart: it was black blood different from that seen in health; sometimes some blood was found in the left heart; but in the arteries almost invariably was found air. A theory of the function of the lungs was that the veins circulated the blood, while the arteries circulated air, obtained from the lungs, to the tissues.

Galen thought that the heart was the source of the body's heat, and that the blood was the oil which fed the flame. He proposed to himself the problem of why the blood on the right side of the heart was of a different colour and consistency from that on the left side, and solved it by a matchless piece of pure imagination — he supposed that the blood was purified by being sweated through invisible pores in the septum between the right and left ventricles; true, he could not see the pores, but, then, he said, you cannot see the pores in the skin, yet we know the perspiration oozes through them. He could not have been wronger if he had discussed the matter with Hilaire Belloc.

These erroneous ideas of the circulation prevailed for many centuries. The dissipation of them and the discovery of the true nature of the circulation of the blood were the work of William Harvey. Harvey's labour was the climax of a good deal of speculation which was rife in the scholastic air about him. His discovery is one of the foundations of modern medical and modern biological science, because no progress of any sort could have been made in physiology until men grasped the idea that the blood was propelled all over the body; after that they could guess that it carried nutriment from the digestive system, and oxygen from the lungs, to the tissues, and that it carried poisons to the kidney for excretion.

The doctrine that the heart propelled the blood gained ground slowly. The Middle Ages, especially the authority of the time, followed Galen slavishly. A very great man, Servetus, proved that the blood was purified not by oozing from the right to the left ventricle, but by being driven through the lungs by the right heart, returning to the left heart by way of the pulmonary vein. For this service Servetus was richly rewarded: he was burned at the stake, by John Calvin.

Several guesses were made at the idea that the left heart drove the blood through the systemic circulation (as distinguished from the pulmonary circulation), but it remained for William Harvey to conceive the idea that the blood was driven by the heart in "a motion, as it were, in a circle," and to prove this by experiment. He tells us how he watched the beating hearts of animals and "was tempted to think with Frascantinus that the motion of the heart was to be comprehended only by God. For I could not rightly perceive at first when the systole (contraction) and when the diastole (dilatation) took place, by reason of the rapidity of the motion, which in many animals is accomplished in the twinkling of an eye." He was able to demonstrate, however, (1) that at exactly the same time when the heart contracts, the arteries give a pulse; and (2) that, as death approaches, and the heart ceases to beat, the pulse also stops; and (3) that when an artery is divided, the blood spurts from it with each systole of the heart. So much for the outgoing blood in the arteries; but he showed also that the blood returned through the veins and that the direction of flow in the veins was towards the heart, the opposite of the direction in the arteries; he redemonstrated Fabricius's discovery of the valves in the veins which prevent the blood from going backwards, away from the heart, by showing that when an arm is tightly bound, the vein can be seen under the skin engorged on the side away from the heart, with little knots marking the site of the valves. If the blood were travelling in the veins from the heart to the extremities, he reasoned, the swelling of the veins would be on the side towards the heart when the arm is bound by a tourniquet. Thus Harvey showed that there was a double channel: in one set of vessels, the arteries, away from the heart; in another set, the veins, to the heart. The black venous blood entered the right heart and was driven through the lungs for purification, was collected into the left heart and driven out into the systemic circulation. The controversy which the scholars of his time raised as to how the blood got from the arteries to the veins was settled nine years after Harvey by Malpighi's discovery of the capillaries, the microscopic thin-walled vessels which connect the small arteries and the small veins.

But the great and final experiment which Harvey performed is set down in the ninth chapter of his book; it is conceived with a simplicity and conclusiveness that is marvellous for the tortured scholarship of the day in which he lived; as he swings into its description his prose takes on a lofty tone, reflecting the majestic happiness of a mind which is proudly conscious of the integrity of its creation. He proposes to measure the amount of blood expelled by the left ventricle with each systole. By measurements on the dead body he found that the left ventricle, in extreme dilatation, would hold a little over two fluid ounces. He supposed,

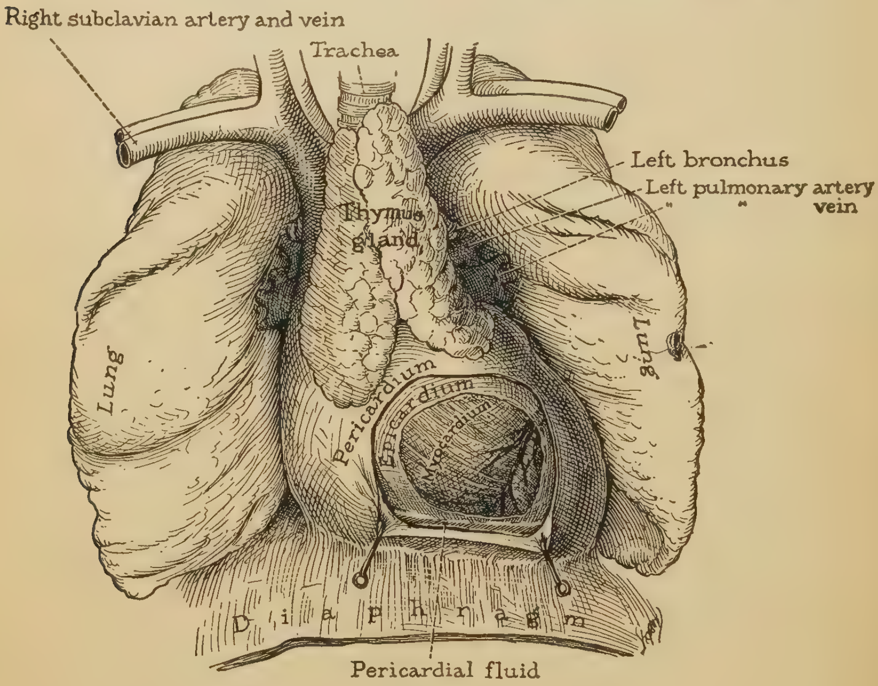

Right subclavian artery and vein
Trachea
Left bronchus
Left pulmonary artery
" " vein
Thymus gland
Lung
Lung
Pericardium
Epicardium
Myocardium
Diaphragm
Pericardial fluid

FIGURE 43

The relation of the heart to the lungs, the main blood-vessels, the diaphragm, the pericardium, and the thymus gland. The dissection is made from a twelve-year-old boy. In the adult the same relations exist except that the thymus gland normally atrophies and no longer exists.

basing his supposition on the difference in size of the contracted and the dilated ventricle, that at each beat it expelled an eighth of its contents. He calculated then that in half an hour, the heart having contracted one thousand times, the amount of blood thrown into the circulation will be ten pounds, five ounces — a greater quantity, he states, than is contained in the whole body. He knew this because he had measured at slaughter-houses the amount of blood which he was able to obtain from a cow, sheep, or pig after the throat was cut and found it to be a fairly constant amount. Modern research puts the total quantity of blood in the human body at about 5% of the body-weight, or 7½ pounds for the average. Butchers, says Harvey, are well aware that after cutting the throat of an ox and dividing the vessels of the neck, in less than a quarter of an hour the whole body is bloodless. If all this be true — and in its simplicity it is irrefutable — if blood is constantly in the body, if it is moved by the heart, if the chambers of the heart expel a quarter of an ounce at each beat, if this amount is expelled seventy-two times a minute, then in half an hour the heart will expel ten pounds of blood; and if the amount of blood in the body is a fixed amount, and if that amount of blood in the body is less than the amount expelled by the heart in half an hour — then the blood must constantly return to the heart and be redistributed.

Thus was the great central fact about the physiology of the circulation established. Everything that has been added since is mere embroidery.

The anatomy and physiology of the circulatory system may be summarized in a short space. The system in general consists of (1) the heart, which lies in a protective sac, the pericardium, and of (2) vessels, (a) the arteries, which receive the blood from the heart (the largest of these, the aorta, receives blood from the left side of the heart and, breaking up into smaller divisions, carries the blood to all parts of the body; and the next largest is the pulmonary artery, which receives blood from the right side of the heart, which blood it carries to the lungs to be aerated); (b) the capillaries, which are the smallest division of the blood-vessels; and (c) the veins, which return blood to the heart.

The heart is a thick-walled muscular organ. It is enclosed, as has been said, in a protective fibrous sac, the pericardium; over the surface of the heart, and over the inner surface of the pericardium, is a serous membrane, which secretes a thin lubricating fluid; the presence of this fluid facilitates the constant beating of the heart inside the pericardial enclosure. The inside of the heart is lined with a similar membrane, the endocardium. There are four chambers to the heart, two smaller ones, the auricles, and two larger ones, the ventricles. The auricles receive the blood from the veins, the ventricles force it into the arteries to be distributed all over the body.

The blood from the heart, the extremities, and the liver is collected in two large veins, the superior and inferior vena cava, and these empty into the auricle on the right side. When the right auricle contracts, it forces its contained blood past the tricuspid valve, which separates the right auricle and the right ventricle, into the right ventricle. When the right ventricle contracts, it forces its contained blood past the pulmonary valve into the pulmonary artery. The pulmonary artery carries the blood to the lungs, where it passes into capillaries, which spread out over the wall of the air sacs, and thus allow the venous blood to give up its carbon dioxide and take up oxygen. After this exchange occurs, the blood is collected into larger and larger vessels, which finally coalesce into the pulmonary vein. The pulmonary vein empties its blood into the left auricle. When the left auricle contracts (synchronously with the right auricle), it forces its contained blood past the mitral valve, which separates the left auricle from the left ventricle, into the left ventricle. When the left ventricle contracts, it forces its contained blood past the aortic valve into the aortic artery, or, as it is usually called, the aorta. The aorta gives off first small arteries — the coronary arteries — which nourish the heart-muscle; next the innominate artery, which subdivides into the right subclavian, which carries blood to the right arm, and the right carotid, which distributes blood to all parts of the right side of the neck, face, head, and brain. Other divisions of the aorta go to the left side of the neck, head, etc., to the left arm, to the chest wall, to the liver, stomach, intestines, spleen, and kidneys, to the pelvic organs, and to the legs. These arteries finally break up into capillaries, which recoalesce into veins. The veins, getting larger and larger, bring the blood towards the heart, until the two largest, the superior and inferior vena cava, empty into the right auricle — and we are back where we started (Figure 42).

The mechanics of the circulation are evident enough, once the thought of a complete circuit of the blood is grasped. There are in reality three circuits of the circulation: two — the pulmonary and the systemic — have been mentioned; the third — the portal circulation — the gathering up of blood from the intestines, which passes through the liver before entering the right auricle, is really a branch of the systemic. Each consists of a set of arteries, capillaries, and veins. The arteries are thick-walled elastic vessels which carry the blood from the heart, and which divide and subdivide, growing thinner walled all the time until they become the tiny capillaries in the tissues, through whose membranous walls oxygen and carbon dioxide are exchanged between the tissues and the blood and through which same walls food is given to the tissues, and waste products returned to the blood; these capillaries finally coalescing to form the veins through which the blood is returned to the heart. In the arteries the blood flows rapidly — 300 millimetres per second — in the capillaries it oozes along sluggishly, as can be seen by watching the web of a frog's foot under the microscope, at the rate of .5 millimetre a second; in the veins at a more and more rapid rate as the heart is approached — 61 millimetres per second in the femoral vein, 147 in the jugular. The time consumed in a complete circulation has been calculated by injecting an easily recognizable substance into the jugular vein on the right side and removing blood from the jugular vein of the left side until the substance appeared. How surprised William Harvey, with his half-hour unit, would have been to be shown that in the horse this requires only 28 seconds! (For capillaries and the transition from arteries to capillaries to veins see Figures 26 and 53.)

The heart itself is a muscular organ, designed like all muscles to do work. The work done by both ventricles of the heart in 24 hours has been calculated by a conservative physiologist at 14,000 kilogrammetres (remember your physics, that the unit of work is a foot-pound, the work done in raising a weight of one pound through one foot: the kilogrammetre is 7.2 foot-pounds). This is sufficient work to raise a man of 150 pounds twice the height of the Woolworth Tower. The 24-hour stint is done second by second.

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The action of the heart valves can best be understood by studying the diagram (Figure 44). When the auricle contracts, the mitral valve is forced open, allowing the blood to pass into the ventricle. When, a tenth of a second later, the ventricle contracts, it forces the valve shut, preventing the blood from flowing backwards into the auricle. The blood is projected by the contraction of the ventricles into the two great arteries, the pulmonary artery on the right, and the aorta on the left; at the mouth of each of these vessels is another valve, which opens to allow the blood to pass out, and which during dilatation of the ventricle is closed by the weight of the column of blood in the vessel, preventing any blood from returning to the ventricle.

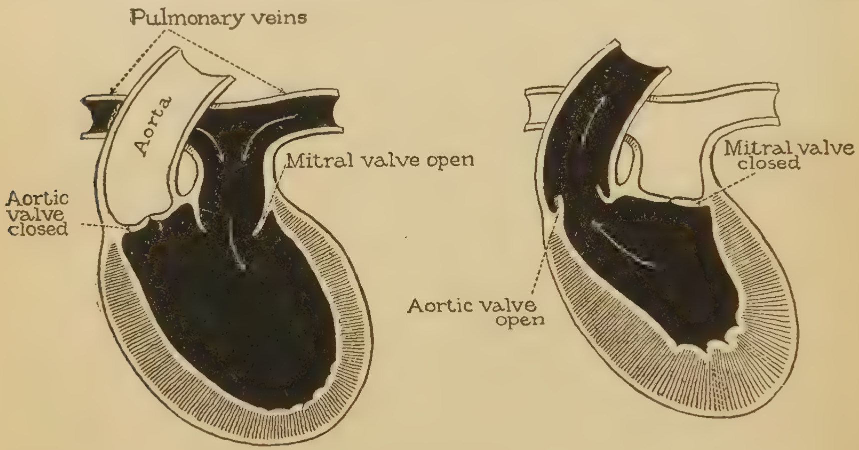


FIGURE 44

Diastole and systole in the left heart. Note the positions of the two valves in both cases. Diastole to the left, systole to the right.

The mechanism of the heart, or, in other words, what keeps the heart beating, is a subject about which many pertinent facts have been discovered. It is known that two sets of nerve-fibres go to the heart, and that stimulation of these nerves by various substances, notably drugs, will either slow or hasten the heart-beat. When the vagus nerve is cut and the cut end stimulated by an electric battery, the heart will first slow down in rate, and when a stronger current is applied, come to a complete standstill; the vagus is therefore considered as an inhibitory cardiac nerve. When the nerves from the sympathetic nervous system to the heart-muscle are stimulated, the action is exactly the opposite — the heart-rate is increased, and when they are cut, the heart-rate is decreased. In the latter case it may be noted that the removal of the accelerator influences gives the depressor influences full sway. This balance between two sets of nerve-fibres is an important thing to remember, as we shall see it again in the study of the vegetative nervous system, of which the heart nerves are a portion. These nerves, be it noted, are automatic in their action, are not under the control of the will, and send no fibres to the higher nervous system.

The hypothesis that the heart is kept beating by the balance of nervous impulses is, however, not entirely in accord with all the facts known. Strips of heart, at least of coldblooded animals, removed from the body can be kept beating in properly prepared solutions, and the hearts of experimental animals entirely severed from their nerve connexions will beat for hours, changing their rate from fast to slow as the solutions which are run through them are changed in chemical content — potassium stopping the heart, sodium reviving it. The heart-muscle, besides possessing the property of contractibility, also possesses the properties of rhythmicity and conductivity. When no nerve impulses go to it, it will beat regularly and rhythmically.

The heart-beat, after being initiated at the top of the auricle, passes over the heart to the ventricle, the wave of conduction being carried along over a special bundle of muscular and nervous tissues, called the neuromuscular bundle of His. We shall consider it more at length under the heading of heart-failure. If it becomes diseased, as from the lighting on it of infection from an abscessed tooth, curious things are likely to happen. The condition is known as heart-block, because the impulses are blocked in their passage from the auricle to the ventricle, and the ventricle begins to beat on its own rhythm, which is always much slower, as slow as forty or, in one case I saw, twenty a minute.

If you wish to get a visual image of the nature of the contraction wave passing over the human heart, watch a caterpillar crawling up a screen. One segment after another elongates and then contracts, the wave rippling over the animal body with a beautiful precision, but there is always one point at which a maximal contraction exists. In the heart this same sort of contraction wave starts at the top; it is conducted by the bundle of His, the auricles contracting first and then the ventricles. Presumably as the wave passes over the bundle of His, impulses are distributed from the point of maximum stimulation of the bundle to the adjacent cardiac muscle-fibres, causing them to contract.

There is an old nonsense-verse about an introspective centipede who became worried for fear the mechanism which arranged the orderly movements of his legs would break down. So he began to give the matter thought. As soon as he did so, his legs got tangled into an inextricable mess. It is so with the heart. Sometimes a neurotic patient will begin to worry about his heart-beat and will pick up the very bad habit of counting his pulse. As soon as he does so, he is lost, because then the heart really does begin to drop beats and get tangled up. The extreme case is that of Colonel Townshend, as reported by the bluff old English physician George Cheyne in 1733, in a book called *The English Malady: a Treatise of Nervous Disorders of all kinds, as Spleen, Vapours, Lowness of Spirits; Hypochondriacal and Hysterical Distemper.* The fascinating Colonel informed Dr. Cheyne that he was able

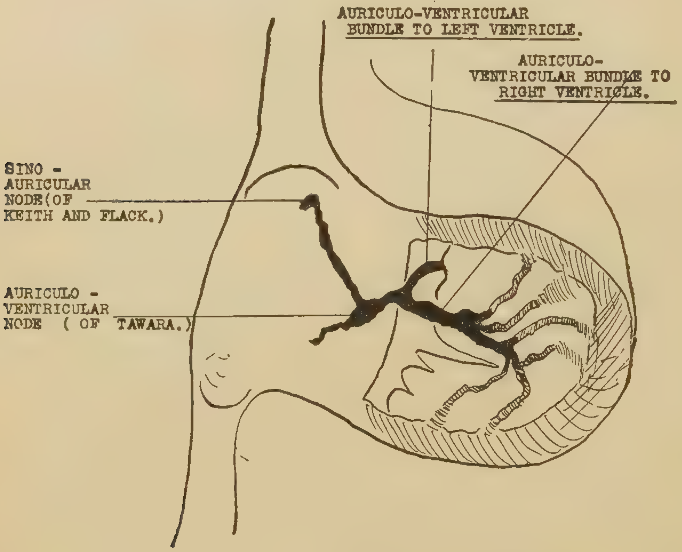

AURICULO-VENTRICULAR BUNDLE TO LEFT VENTRICLE.
AURICULO-VENTRICULAR BUNDLE TO RIGHT VENTRICLE.
SINO - AURICULAR NODE (OF KEITH AND FLACK.)
AURICULO - VENTRICULAR NODE (OF TAWARA.)

FIGURE 45

Diagram of the neuro-muscular bundle of His in the heart.

to stop and start his heart at will, and offered to give a demonstration. He "composed himself on his back, and lay in a still position some time. . . . I found his pulse sink gradually, till at last I could not feel any, by the most exact and nice touch." There was "not the least motion in his heart," nor "the least soil of breath on the bright mirror" held in front of his mouth. This continued half an hour. Then the Colonel began to revive, and the pulse and respiration returned. But some inner voice, or perhaps some wraith in that land of shadows in which he had been dwelling, whispered the Colonel that the experiment had been tried once too often. He made his will, received the last offices of the Church, and died, permanently and completely, on the evening of the day on which the test was made. *De te fabula.*

The circulation away from the heart — i.e., in the vessels — is controlled in general by the laws of hydrostatics. The great arteries divide into two or more branches. The cross-section of any single branch artery is always smaller than the stem artery, but the combined diameter of all the branches is always larger than the diameter of the stem. Finally, when the capillaries are reached, each one is smaller than any artery, but the total cross-section of capillary area is 800 times the size of a cross-section of the aorta. The heart then is compelled to exert a force which will pump blood into an ever widening stream-bed. It would be impossible to do this did not the arteries have elastic walls. As soon as fluid is forced into an artery, its walls first dilate to accommodate the increased bulk and then exert pressure on their contents. This pressure forces the blood onward smoothly and continuously.

The arteries also have muscular fibres in their walls. These muscular fibres are supplied by two sets of nerves, the vasomotors, one set of which will cause the arteries to contract and one set to dilate. These functions were first discovered by the great French physiologist, Claude Bernard, who, in 1851, showed that when the sympathetic nerve in the neck of a rabbit is cut, the blood-vessels in the ear on that side become very much dilated, and that if the nerve be stimulated by electricity, the ear becomes blanched, because the arteries contract. This fact has important bearings: it is probable that the blood-supply to an organ determines its functional activity; for instance, Bernard also showed that if the chorda tympani nerve in the face is cut and the end stimulated, the blood-vessels of the salivary glands dilate and also an increased flow of saliva occurs. The vegetative or automatic nervous system regulates the blood-supply to all the organs, filling them with blood when their work is needed, draining the blood from other organs. For instance, a full meal after exertion induces sleepiness — the blood goes from the brain and muscles, and floods the digestive organs. It is probable, but not completely proved, that the veins and capillaries also have vasomotor nerves and control.

The factors which must be counted, therefore, in the maintenance and variation of the circulation are: (1) the strength and (2) the rate of the heart-beat, (3) the pressure exerted by the elastic arteries, and (4) the varying size of the vascular bed, as controlled by the vasomotor nerves.

DISEASES OF THE HEART AND BLOOD-VESSELS

Of the many derangements of the heart and vessels, we shall have an opportunity to consider only a few — and we shall select the commonest and most important. For the heart we shall choose heart-failure, because that is the central fact about the deranged heart and in inquiring into the cause of heart-failure we shall touch upon most of the diseases which affect the heart. And for the vessels one of the commonest of all conditions, known variously, although the terms are not exactly synonymous, as high blood-pressure and hardening of the arteries. A third condition, angina pectoris, which partakes of both heart and vessel disease, will be considered last.

CARDIAC FAILURE: The heart is really a very tough organ. It has enormous powers of adjustment both to the body's needs and to the inroads of disease. It is always capable, with certain exceptions, of doing a great deal more work than it is at any moment accomplishing. The exceptions may be said to be in general of two kinds. First, when the body is at a point of maximal exertion, as in fast running: here, obviously, a point will be reached when the heart, in order to supply the body with blood containing oxygen, is doing all it can. Second, either disease of the heart-muscle or diminution of the elasticity of the arterial walls will reduce its compensatory powers.

There is a close relationship between three functions of the body — the total metabolism, the total amount of respiration, and the total output of blood from the heart. When the body begins to exert itself, when a muscle contracts, it obtains its energy by burning food. Food is burned, as everything is burned, by uniting with oxygen. The working muscle therefore needs more oxygen and gives off more carbon dioxide than the resting muscle. It obtains this oxygen from the blood, which in turn obtains it from the lungs. When exertion is begun, therefore, more blood is needed all over the body, and the pulse-rate and the respiratory rate go up. More blood per minute is being thrown into the circulation — both into the muscles, whose blood-vessels dilate, and into the lungs. The total capacity of the heart (to throw out blood per minute) varies in different individuals, and in the same individual with training — athletic training. But in any individual there is at any given moment a definite total capacity of the heart. When the exertion is vigorous enough, or continued long enough, a point will be reached when this total capacity of the heart is reached. Then the exertion must either cease or be reduced, or collapse will occur.

This physiological heart-failure almost never occurs in practice — the individual is so distressed as to stop his exertion before failure occurs. But a thorough understanding of the possibility of the condition is fundamental for a knowledge of heart-failure under pathological conditions.

In the last analysis, heart-failure is failure on the part of the heart to throw out the amount of blood per minute necessary for the body's needs. The causes of heart-failure are numerous. First, purely mechanical derangements of the heart's mechanism may add to the heart's work and finally break it down. An instance of this is valvular disease, so that leakage through a valve throws an extra burden on the heart. Another is rise of the resistance to the outflow of blood from the heart, or, in other words, high blood-pressure. Second, disease may attack the muscle of the heart itself, prevent its smooth functioning, and reduce its capacity. Third, an interference with the blood-supply of the heart may occur, for the heart-muscle, like all other muscles, must be supplied with blood. A form of heart-failure characterized by pain and called angina pectoris is caused by stoppage of the vessels supplying the heart. Fourth, the heart and its vascular system may be affected by poisons. Examples are the toxins from the infectious diseases, particularly pneumonia and peritonitis, resulting in a state called shock or collapse. A similar state is induced by a heavy blow, especially a blow on the abdomen, and may arise in the course of surgical operations when it is necessary to handle the intestines; it is called surgical shock. Another poison which affects the heart is a perverted form of secretion from the thyroid gland occurring in exophthalmic goitre and resulting in the very rapid pulse of that disease. "Smoker's heart" and "athletic heart" are, so far as I know, either neuroses or myths.

VALVULAR DISEASE of the heart is the result of bacteria of some kind (the commonest infections are rheumatism and syphilis) lighting on the delicate valve leaflets and causing inflammation; when the inflammation subsides, scar tissue is laid down, as is the case with inflammation everywhere, and the valve affected contracts so that it no longer can cover the opening (insufficiency), or the entire orifice is narrowed (stenosis). The heart valves are simple in character, opening only one way: when pressure is exerted on one side, as by the contraction of either an auricle or a ventricle, they open, allowing the blood to pass them; when pressure is exerted on the other side, they close tightly, preventing the blood from running back against stream. When disease attacks them and the edges shrivel, the closure is not complete and the blood does run backwards, as from the left ventricle, during its systole into the left auricle, when there is insufficiency of the mitral valve. The act is called regurgitation; in this case, mitral regurgitation. It occurs at every beat of the heart, some of the blood flowing backwards, in the wrong direction. Naturally it imposes a mechanical defect on the heart, because at each beat the heart must throw out enough blood to maintain the systemic circulation in spite of the fact that it loses some of its load into the other chamber.

The mechanical difficulty imposed by HIGH BLOOD-PRESSURE is of a somewhat different sort. Here the resistance to the outthrust of the heart is increased, and at each beat it has to do more work in order to get blood into circulation.

In either kind of mechanical difficulty (valvular defect or heightened pressure to be overcome) the net result is the same, the heart is compelled to do more work. Now, the heart is a muscle. Like all muscles when there is more work to do, it does the work, but, in order to do so, it hypertrophies, or enlarges. Enlargement of the heart, therefore, is a purely compensatory process. Unless the heart did enlarge, death would occur. People are constantly coming to doctors because they have been told their hearts were enlarged, in order to get some advice as to how to reduce the enlargement. If it were reduced, they would be in terrible condition. With this compensatory hypertrophy of the heart established, life may be maintained comfortably for long — incredibly long — periods of time — twenty, thirty, forty years. The entire capacity of the heart is increased so that it is capable of doing more work than an average heart. Eventually, in most cases, with the onset of age-changes in the heart-muscle, compensation, as we say, breaks down and heart-failure or decompensation does occur.

The symptoms of heart-failure are four. The earliest symptom, either of permanent or temporary heart-failure, is *shortness of breath*. It is exactly what occurs to the runner. His total metabolism goes up, the heart has to work more, and his breathing is more rapid. In heart-failure the metabolism does not go up, but the heart capacity goes down. Then the other leg of the stool, the respiration, must go up to compensate. *Dropsy*, or fluid in the tissues, is the second symptom. The fluid is blood-serum, exuded out into the tissue spaces because of the stasis, or slowing, of the blood-stream. It occurs first in the ankles, because these are the most dependent, or farthest away from the heart, and gradually creeps up the leg, then into the abdomen. *Irregularity of the pulse* often occurs — a symptom which is explained below. Finally *cyanosis*, the fourth of the great symptoms of heart-failure, a blueness of the skin due to lack of oxygenation of the blood, completes the picture.

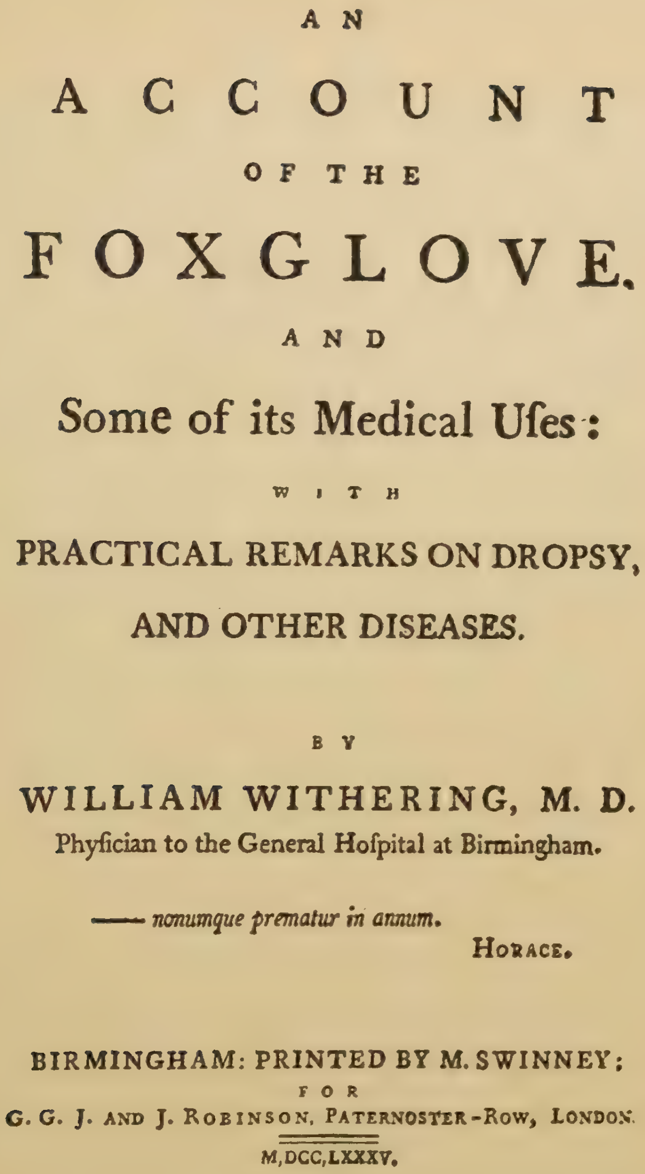
In myocardial degeneration, or disease of the heart-muscle, the same symptoms may occur. The most frequent causes of myocardial disease are (1) the deposit of scar-tissue around sclerotic or hardened arteries and capillaries (atheromatous change), and (2) spots of localized infection, the infection originating in an infected tooth or tonsil or gall-bladder. Spots of this kind in the heart-muscle will do damage to the extent that they involve the vital parts of the heart-muscle. If they are located on the neuromuscular bundle of His, they will do more damage than if located elsewhere. If they hit a certain place in the bundle of His, they will interrupt or block the smooth conduction of the impulse; the auricles will then beat, but the impulse to contract will not reach the ventricles. Under this circumstance the ventricles will set up a rhythm entirely independent of the auricles. The condition is known as heart-block.

The treatment of heart-failure due to these causes is quite satisfactory, and life can usually be prolonged for many years even when complete heart-failure with dropsy has supervened. In the severe state, the employment of rest must seem logical. To understand this we must return to our lesson of the three functions — metabolism, respiration, and circulation — which go hand in hand and are adjusted to the amount of exertion. In heart-failure the power of the circulation is lowered. Therefore we cut down the metabolism to suit its needs. That means rest.

In less severe forms the heart may need, on the contrary, graded exercise. The heart-muscle becomes stronger with exercise. The detection and removal of focal infections from the teeth and tonsils, etc., may prevent further damage to heart and vessels.

There is one great drug that can be used in heart-failure — digitalis or foxglove. The story of its introduction into medicine is interesting and instructive. Its early history is recorded in a fascinating old pamphlet published in 1785. The author of that pamphlet was William Withering, M.D., of Birmingham, England. Withering had one of the hardest and soundest minds ever bestowed upon a human being. Incidentally, not as any part of the narrative, he was a member of the congregation of Joseph Priestley, the discoverer of oxygen, whose real business in the world was that of a sort of Unitarian minister. Other of their associates were James Watt and Erasmus Darwin.

In Withering's *Account of the Foxglove* there is the full story of the introduction of this great drug into medicine. The foxglove grows best in the cold, wet summer climate and soil of England. Withering tells us that he had heard for some time of an old woman in Shropshire who brewed a tea of herbs which was used for drospy. He felt at first that the reports of its efficacy were exaggerated,



AN

ACCOUNT

OF THE

FOXGLOVE,

AND

Some of its Medical Uſes:

WITH

PRACTICAL REMARKS ON DROPSY,

AND OTHER DISEASES.

BY

WILLIAM WITHERING, M. D.

Phyſician to the General Hoſpital at Birmingham.

—— *nonumque prematur in annum.*

HORACE.

BIRMINGHAM: PRINTED BY M. SWINNEY;

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M,DCC,LXXXV.

FIGURE 46

Title page of the first description of foxglove or digitalis, the heart tonic.

and that those who believed in it were credulous. But something happened to bring his mind up standing — "accelerated his interest," as he said. The narrative in his monograph is condensed and I shall take the liberty in recounting it to read somewhat between the lines.

It appears that the Dean of Brasenose College, Oxford, fell sick of the dropsy, and called in the best medical consultants he could find. But they did him no good, and so he was pressed, probably by some solicitous and possibly female member of his household, to use a tea brewed by the old herb-woman in Shropshire. The Dean in all likelihood reflected, tossing upon his canopied bed, that he had given the regular medical profession every chance and that he was under no further obligation to continue their administrations. At any rate, he consented to use the old herb-woman's remedy, with the gratifying result that his dropsy disappeared.

This was the circumstance which "accelerated" Withering's interest. His next step was to obtain the recipe of the tea. I imagine that this was not so easy. The old woman unquestionably made a good living from it. She was attended by an enormous reputation. She probably guarded her secret very, very zealously. I like to dwell upon the possibly sinister devices with which those two compact and stubborn intellects conducted their contest — he to get, and she to keep. Bribery is more than likely; theft far from improbable. It is insipid to think that the business was achieved by the easy bamboozling of a simple old woman by a great gentleman alighting from his coach, clinking a pair of gold pieces in his pocket.

By whatever means, he did obtain the formula. He says that it contained many ingredients, but that from his knowledge of the others he concluded that the active one was the root of the foxglove. Then he began to try this out, and he tried also to find out whether the stem, the leaves, or the flowers were not more regular and livelier in the desired action than the root — tried them out by using them on patients, if you please. I do not mean to hint that he caused the death of any of these patients. I do not think he did, though he tells us quite frankly of one patient who almost died. He finally decided that the leaves contained most of the active principle — and that fact is fortified to-day by thousands of independent re-examinations. He then attempted to formulate some rules for determining the proper dosage of digitalis-leaf tea. He advised that the administration be stopped when certain symptoms appeared; one was when the pulse became more regular and slower; one was when nausea and vomiting set in. He made several other investigations, all of which he set down, with a long list of case histories, in the little book published in 1785.

Now, notice the difference between Withering's knowledge and that of the old woman of Shropshire. His contribution represents the second stage in the accumulation of knowledge of any drug. The old herb-woman knew that the tea made in a certain way was beneficial in cases of dropsy. She followed slavishly the exact formula originally used; she made no variations, she made no experiments. But Withering did. He found out which herb did the work, he found out what part of that herb was the most active, he found out the rules for its proper administration, he found what kind of cases seemed to respond best. In other words, he rationalized the usage of the drug. But there were still immense holes in his knowledge. He knew almost nothing of the nature of dropsy. He did not suspect at all that the drug acted on the heart. He knew nothing of the minute anatomy of the heart; no one in his time did. There was not a decent compound microscope then in existence; there was, consequently, no suspicion that animal tissues were composed of cells, each with definite chemical reactions. It was the next twelve decades that supplied the knowledge needed for a complete understanding of digitalis.

During the nineteenth century it enjoyed various changes of fashion. At times it was completely neglected. But towards the end of the century it became pretty definitely established as a heart tonic, though the understanding of its action was small. About 1900 an event of first-rate importance in its history occurred — another man of genius turned his attention upon it. This was James Mackenzie, a general practitioner in the midlands of England. Being a general practitioner, he was able to watch patients with heart-disease over a period of many years. Mackenzie lived in the same town, often in the same square, with his patients. He became very much interested in heart-disease, and especially in irregularities of the pulse, and he invented a little instrument for the recording of these irregularities. He marked out one in which digitalis acted particularly efficaciously. He did not entirely understand its mechanism — he called it an "absolutely irregular pulse" — but he was able to recognize it by certain signs, and these signs he recorded.

About 1908 Mackenzie decided to remove to London and set up as a specialist in heart-disease. He cut a queer figure there: he did not wear the regulation silk hat and frock-coat of the London consultant, but a soft slouch hat and a rumpled tweed suit. The bright young men who had been working on the heart and had kept popping out of their laboratories with acid stains all over their fingers to announce the ionic content of solutions in which strips of turtle heart had been beating for a hundred and twenty hours did not know what to make of this combination midwife, cardiologist, and surgeon, who had actually studied human disease on sick human beings: they blinked at him once or twice and darted back to their laboratories to continue their observations on the gaseous exchanges in the capillary circulation of newts.

But then a very fortunate meeting occurred. Arthur Cushny, an astute man who had been working on the action of drugs for many years, was at the University of London. He became interested in Mackenzie's work, and soon produced in dogs, by the electrical stimulation of the auricular part of the heart, a condition of fibrillation which resulted in an irregularity of the pulse exactly like the irregularity Mackenzie described in human beings, and in which digitalis was so especially effective. Cushny invited Mackenzie to his laboratory and showed him the tracings. Mackenzie agreed that the conditions were the same — and the last chapter in the history of our knowledge of digitalis opened.

To understand this we must go back a little and remember the insight that had been acquired by His, a German, by two Englishmen, Keith and Flack, and by a Japanese, Tawara, into the finer anatomy of the heart. These men found that the beat of the heart is a contraction wave beginning in the upper part, the auricles, and coursing downward to the lower part, the ventricles. The track over which this wave passes is a small bundle of muscular and nervous tissue called the bundle of His. It is now known that digitalis, when absorbed, makes a chemical union with this structure. It picks it out from all the other parts of the body and paralyses or blocks it. This fact explains how the drug acts in heart-failure. When the heart is diseased, there often sets in that quivering of the auricles which was described by Cushny. The impulses then pass over the bundle of His so rapidly that the ventricles, which drive blood out into the body, respond very irregularly and very ineffectively. The amount of blood actually in motion is greatly reduced. Blood accumulates in the vessels and dropsy results. But when digitalis is given, there results a block of the conducting bundle, the bundle of His, the ventricle is protected from the incessant bombardment of the auricular impulses, it begins to beat more regularly, it re-establishes the flow of blood in the vessels, and so the dropsy, and the other symptoms of heart-failure, disappear.

A perfect epidemic of investigation of digitalis followed the publication of these facts. Hatcher and Brody, two Americans, in 1910 laid down a method of standardizing the strength of a given sample. The leaves of digitalis taken from two different plants in different parts of the world, in different years, may have entirely unequal concentrations of the active substance. It will not do simply to weigh them, as we weigh drugs of uniform chemical composition. Five grains of one leaf may be totally unequal to five grains of another. Hatcher and Brody perfected a method to determine the activity of a sample by observing its action on animal hearts. Cary Eggleston, of New York, in 1915, gave out a method of dosage, now generally followed, by using a sample of known strength administered according to the weight of the patient. Canby Robinson, now at Vanderbilt University, determined how soon after a dose of digitalis was swallowed it was absorbed and began to work. Pardee, of New York, determined how much of a dose was wasted by elimination and how much actually utilized by the body. This is only a fraction of the work accomplished or now in progress.

The results of the treatment of heart-failure by these means — rest, removal of focal infection, graded exercise in appropriate cases, a bland and easily digested diet, and drugs, of which digitalis is the most important — are much better than might be expected, considering that so "vital" an organ as the heart is concerned. As was pointed out above, the heart has enormous powers of recuperation. It can "stage a *come-back*" better than most organs in the body. Many patients with badly crippled heart valves and heart-muscles are kept alive and in relative comfort for years by these means. No one need be made despondent by the verdict "You have heart-disease." To borrow a slogan, from the desk mottoes — "The heart may be down, but it is never, or (in deference to the critical sensitiveness of the crew of the *Pinafore*) almost never, out."

HIGH BLOOD-PRESSURE has taken its place, like those other things of the spirit such as the weather, the menopause, the income-tax, and the total depravity of grandchildren, as a staple topic of conversation on the porches of summer cottages and in the lobbies of winter hotels. I have been made privy to a number of these dissertations, and, in fact, have been pressed into service as umpire or arbiter of not a few. They illustrate, it occurs to me, two defects of an over-civilized civilization such as ours. One is that in a high state of civilization the amount of data accumulated on any one subject is apt to become too weighty for the mental equipment of an average participant of that civilization. It requires a wide knowledge of biology, of heredity, of cytology, of chemical pathology, and of physiological physics — to say nothing of a comprehensive sympathy with human nature — to encompass a catholic understanding of hypertension, and these attributes I have not found conspicuous either in the informal discussions to which I have alluded or even, I regret to divulge, in the more episcopal consideration I have heard given to the subject in the halls of learned medical societies.

The other defect which the subject illustrates may be called the doctrine of the machine. By this is meant a certain passionate acceptance of the belief that a machine can do more for or tell more about a human being than another human being can. In the good old days before James Watt dozed by the tea-kettle, when men were transported by horses driven by coachmen and sedan-chairs carried by bearers, a person who had any of the symptoms of high blood-pressure would be told by his medical adviser that he was somewhat gouty, that goutiness affected different people in different places, that he was gouty in the breathing-apparatus, and possibly the kidneys, that these things were inevitable but would probably not get worse for a long time, and that he should abstain from more than one glass of port after dinner. In the present age of enlightenment the patient (who has usually had no symptoms, but whose high blood-pressure has been discovered by a life-insurance examiner or a health extension institute) finds on a visit to his doctor that his blood-pressure this week is 190 when last week it was 185. Here, you see, the poison of the doctrine of the machine begins to operate. The machine, so the patient considers, is more accurate, less influenced by emotion, than a human adviser, and therefore its information must be more trustworthy. Even if his physician follows the example of his eighteenth-century predecessor and says that as a matter of human experience he has seen a good many of these patients, that minor fluctuations are not very important, and that in general his case is proceeding satisfactorily and that it requires nature a long time to take its course in such matters, even that would not completely comfort the patient, for there is the verdict of the awful, inhumanly accurate machine; so the sky is overcast, and the sun is darkened, the remembrance of the dental extractions and the gall-bladder drainage and the intravenous radium is bitter in the nostrils, and the children had better not ask for the use of the car when he gets home.

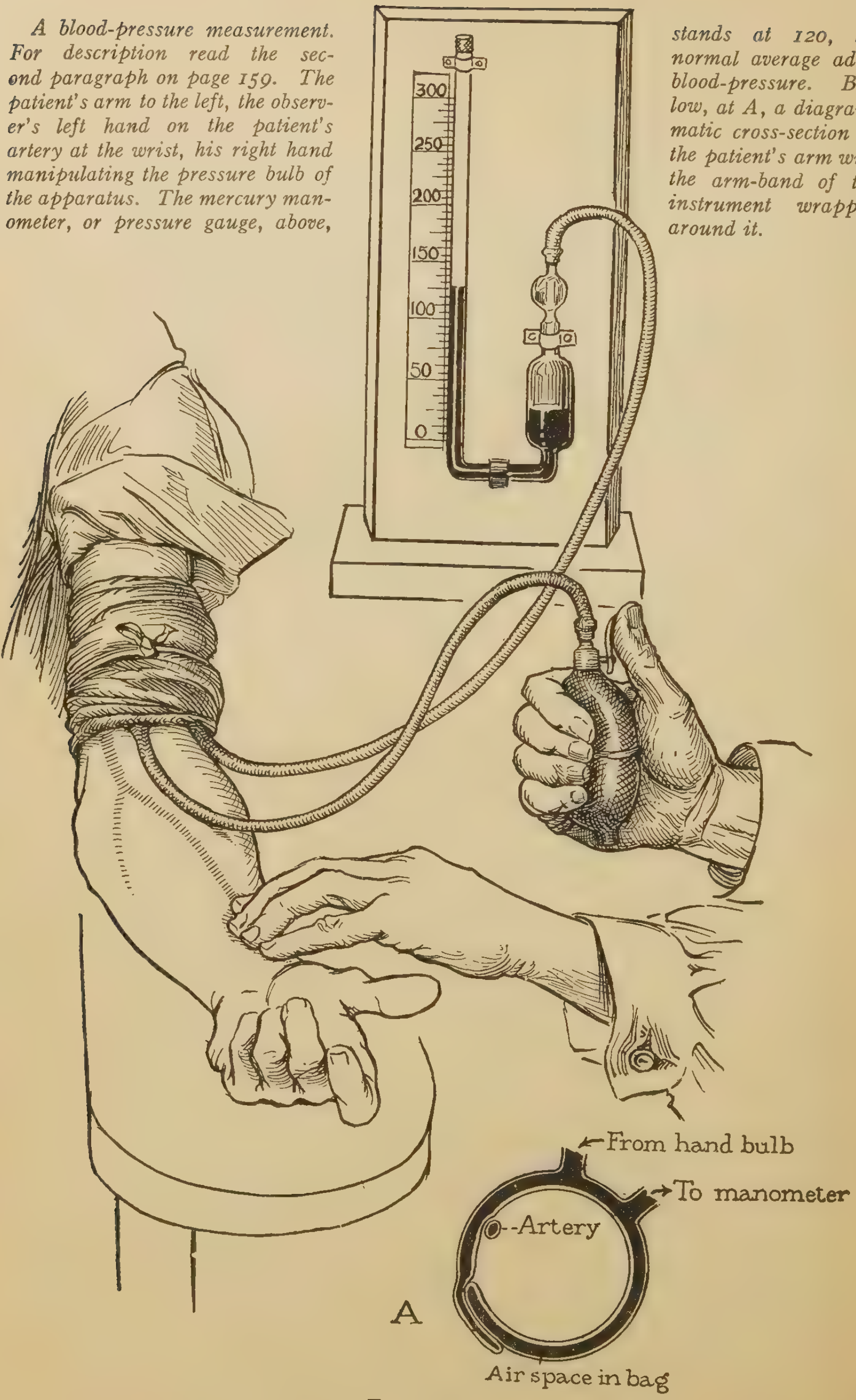
These two difficulties augment each other in preventing an understanding of the subject of high blood-pressure, and of the kindred subject of hardening of the arteries. The fact that a machine is used tends to accumulate data, and the wood itself can hardly be seen for the trees. For what, after all, are these mysterious things — high blood-pressure and hardening of the arteries? Merely the process of growing old. That and nothing more. Why all the pother? Why all the delicate mercury instruments, why the chemical tests of the blood, why the breathing into vital-capacity machines? Simply because the process of growing old is a very complex and fascinating series of bodily changes. That is why it interests a scientific mind, because the scientific mind sees these changes in terms of something even more mysterious — of protoplasmic inhibitions, of the metaplasia of elastic cells, of the accumulation of guanidine, of the rapidity of gaseous exchange. That is why all the gabble of their doctors befuddles the old ladies and gentlemen on the porch — because they see it only in terms of their own individual danger.

Let us take an example in another form of animal life, since the associations so far as they apply to the human body are too painful. There is a certain species of fish in Alaska which live only one season. In May the eggs hatch out, and the young fish dart and glint through the bright sunlit waters. The females lay eggs in late August, which are fertilized and rest over until the next spring before hatching. After the eggs are deposited and fertilized, a strange lethargy seems to settle upon the adult fish, who were born only a few weeks before. They swim sluggishly now, they will be found resting half on their sides in sunny coves. They are not lifeless, because they will with an effort get away if frightened. But at last one after another is washed up dead upon the beach. What has happened to them? It is no explanation to say their time had come, and according to the rules of nature they died. What happened inside them? They were not infected with any germ or any parasite or any poison. No! some subtle creeping change had come over all the tissues of their bodies. We do not know exactly what it is in the fish because we have not been sufficiently stimulated to study it. But we have been so stimulated to study the process in humans. And what we find it consists in is in some a rise of blood-pressure and certain chemical phenomena in the blood, and in others a slow deposit of fibrous tissue in the place of elastic tissue in the whole body, but particularly in the arteries.

High blood-pressure and hardening of the arteries are not necessarily the same thing. The difference between them will be dwelt on in more detail below, but I wish to point the fact out with some emphasis here. Both are processes of advancing years. Hardened arteries may be present in cases of high blood-pressure — in fact I believe hardening of at least the smallest arteries is present in all cases. But hardening of the peripheral arteries may not be accompanied by rising blood-pressure. And people with hardened peripheral arteries — that is, arteries of the extremities, as at the wrist and in the forehead — may live to ripe age. High blood-pressure itself may be of different grades and kinds. Volhard and Fahr, two investigators who have written a monumental treatise on the subject, divide the cases into the benign and the malignant. It seems to me a very useful distinction. For a person to be told he has high blood-pressure is not by any means necessarily as serious as it has come to imply.

Although the measurement of blood-pressure as a part of an ordinary medical examination has been a common practice for only about twenty-five years, the question of the pressure which the blood exerts in the arteries has been discussed for nearly two centuries. Stephen Hales, an English clergyman, in 1733, made some observations on a horse. He did it in the simplest way possible — by putting a glass tube, nine feet long, into the horse's femoral artery. He found that the blood rose 8 feet, 3 inches in the tube, showing that the blood was under a pressure sufficient to support a column of blood of this height. Apparatus much like those used at present were introduced by various physiologists somewhere about 1850, but were used only in the physiological laboratories. About 1900 observations began to be made on men, the clinician adopting the physiologist's armamentarium, as he has often done before and since. By 1905 enough data had been accumulated to make a few life-insurance companies realize that the procedure would be useful to them. Since then many millions of persons' blood-pressures have been recorded, their terms of life from the period of the reading of the pressure noted, and the changes of the internal organs after death examined, so that there is open to the physician an immense accumulation of data about the condition.

The method of measurement of blood-pressure is very simple. A flat rubber bag with two outlets is wrapped about the patient's upper arm. One of the outlets connects directly with a column of mercury. Provided the other outlet is stopped, the pressure within the bag will be recorded by the rise of the column of mercury. The other outlet is fitted with a rubber bulb containing a valve so that the pressure within the bag can be pumped up and then gradually let out at the will of the observer. The observer then puts his finger on the patient's pulse at the wrist. The pressure within the bag is pumped up until the pulse disappears. The bag is now compressing the artery above so much that the pulse cannot come through; it is exerting more pressure than the heart does to circulate the blood. The air in the bag is then let out very slowly until the pulse can be felt. At this point the pressure within the rubber bag is exactly that which the heart exerts to keep the blood flowing in the blood-vessels. Indeed, it is the pressure which the heart *must* exert to keep up the circulation and to keep up life. This pressure is transmitted to the mercury column.



A blood-pressure measurement. For description read the second paragraph on page 159. The patient's arm to the left, the observer's left hand on the patient's artery at the wrist, his right hand manipulating the pressure bulb of the apparatus. The mercury manometer, or pressure gauge, above, stands at 120, the normal average adult blood-pressure. Below, at A, a diagrammatic cross-section of the patient's arm with the arm-band of the instrument wrapped around it.

300
250
200
150
100
50
0
From hand bulb
To manometer
Artery
A
Air space in bag

FIGURE 47

This is the systolic blood-pressure (i.e., during the contraction period of the heart). It is also possible to determine the diastolic pressure, or that maintained during the relaxation period of the heart. This is done by listening with a stethoscope to a succession of sounds heard over the artery during the period of deflation of the bag.

Under all conditions blood-pressure varies with age, and with the emotional and physical condition of the patient. If he is angry, fearful, or excited, if he is smoking a cigar, or has just completed a vigorous set of exercises, it will probably be higher than in moments of calm. The average figure for systolic pressure is around 120 millimetres of mercury for the systolic phase and 80 millimetres of mercury for the diastolic phase.

It rises progressively as age advances. Why? Because in youth the arteries are elastic, but as the body grows old, they become stiffer on account of the replacement of their elastic tissue by fibrous tissue and lime salts. You can keep a stream of water flowing steadily from a rubber hose under lower pressure than you can from an iron tube, because the elastic rubber keeps squeezing down all the time on the water contained inside of it. Under the same pressure from a pump, such as the heart is, the water would flow from the end of the iron tube in squirts. The heart, however, must keep the blood flowing steadily through the body, or life ceases; when the tubing gets stiff, it must keep up a higher pressure than when it is elastic.

This "mechanical" explanation of high blood-pressure has been subjected to certain criticism. It is the explanation in which I personally believe. In other words, I believe that blood-pressure rises with age because of the replacement of elastic tissue by fibrous tissue in the arteries and capillaries. It occurs in certain people at an earlier date than in others on account of hereditary predisposition. In all fairness, however, it must be said that this view is not held unanimously by the medical profession. I shall, therefore, present the objections raised to the mechanical theory, summarize the alternate hypotheses that have been proposed, and indicate in what way I consider them to be inadequate.

The most forceful objection to the mechanical theory consists in emphasizing the two facts that (1) in many cases the arteries which can be examined in the living subject — for instance, at the wrist and in the temples — may be markedly thickened and even so calcified as to have earned the term goose-neck arteries — because the deposit of lime salts gives them a corrugated feeling like that of the windpipe of a goose as one feels its neck — without there being any notable rise in blood-pressure, as determined by the mercury instrument; and that (2) in some of the worst cases of high blood-pressure the same arteries — those which can easily be examined in the living subject — are not evidently increased in thickness. A reconciliation of these apparently opposed facts was made long ago by Janeway, who pointed out that while the arteries of the extremities may be calcified, the great internal vessels, the aorta and its branches, may be still elastic and that they are the crucial points in the cause of the changes.

Hardening of the arteries seems to be a condition which affects arteries in different parts of the body in different subjects, and sometimes it produces heightening of the blood-pressure, sometimes it does not.

O'Hare has, within the last year or two, looked with the ophthalmoscope at the small arteries in the back of the eyes of a number of living patients having hypertension. Irrespective of the condition of the peripheral arteries, these tiny vessels invariably showed thickening when the blood-pressure was high. Along the same line of reasoning was the suggestion made by many men, notably Sir Clifford Allbutt, that in the condition the smallest of all the blood-vessels, the capillaries, are invariably seen to have a deposit of connective tissue, particularly in the kidneys, where we can see them well, and that as the amount of blood in the capillaries is greater than that in all the rest of the blood-vessels, changes in them are concomitantly more important in raising blood-pressure.

Another objection to the mechanical theory is that the cases of the worst type, where the blood-pressure mounts to tremendous heights and the course is steadily downward, appear to have comparatively little change in the arterial walls even when these are examined under the microscope after death. An explanation drawn from what is seen to occur in the physiologic laboratories has been invoked to fit these cases. It is known that the blood-vessels have muscular tissue in their coats and that stimulation of certain nerves will cause a constriction of these muscles, making the vessels smaller and, while the stimulation acts, stiffer. The stimulation of these vasomotor nerves may be accomplished by drugs — as adrenalin — or chemical substances — as barium — or poisons, if you wish to call them that, in solution in the blood. Possibly, therefore, some substances are retained in the blood which cause a continued constriction of the vessels without leaving any permanent changes in them to be observable under the microscope. At any rate the existence of these severe types has led the two acute observers, Volhard and Fahr, already mentioned, to point out that there are two classes of high-blood-pressure cases, which they have appropriately named the benign and the malignant.

Is there any insight into the nature of a poison or poisons which might cause this continuous constriction of the vessels? In answering this we can pass by immediately any such superficial suggestions as those that tobacco, alcohol, salt or red meat may be implicated. The short way with such suggestions is to point out that, much as it may horrify the virtuous, winebibbers and tobacco-users are quite as exempt from hypertension as are the little Roland Reeds, and that vegetarians are affected all over the world in just the same proportion as carnivores. One persistent explanation depends on the fact that the extract of the adrenal glands, adrenalin, is known to be a substance which causes constriction of the vessels and a concomitant rise of blood-pressure; when the adrenal glands are destroyed, as in Addison's disease, an outstanding feature of the condition is low blood-pressure. Vaquez, a French physician, influenced by these phenomena, formulated in 1904 the theory that there is in hypertension a hyperactivity of the adrenal glands, and an increased amount of their secretion. There is little support for such a belief. It is true that certain observers, Aubertin and Austard, and more recently Oppenheimer and Fishberg, found microscopic changes in the adrenals in hypertension, but such observations are too fragile to stand any heavy weight of deduction.

Still another hypothesis rests upon the well-known fact that quite definite changes occur in the kidney in hypertension. It is proposed that since the kidney does not cast off all the waste products of the body under these circumstances, some of those which are retained in the blood-stream act by constricting the blood-vessels all over the body. The difficulty has been to find any bodily waste products which have that property. Batty-Shaw, a famous London consultant, stated quite positively some years ago that there was no intermediate product of nutrition which had a vasoconstrictor action. Major, however, has recently found such a substance in guanidine, which is formed and is normally present in the body at a certain stage in the breaking down of albuminous or protein foods. Guanidine undoubtedly produces a prolonged rise of blood-pressure in animals and men. It has also been found to be present in abnormal amounts in the blood of hypertensive patients.

An interesting corollary of these last-mentioned studies by Major is that he has also found that injections of liver extracts will reduce blood-pressure over quite long periods of time. The theoretical idea at the base of this finding is that we know that the liver has some part in the production of urea. Urea is probably made up by the liver from a number of intermediary products such as guanidine. The supposition is that for some reason the liver fails to form urea out of these products and they circulate as such in the blood. We know they will raise the blood-pressure. Liver extract in the blood will synthesize them into the non-poisonous urea, and, the pressure-raising substances being taken out of the blood, the pressure will fall.

There, so far as the experimental pathologist is concerned, the matter more or less rests. But the experimental pathologist is not the only one who has a right to a view-point on a clinical problem. The physician who sees great numbers of these patients also has an opinion. And one of the things which he sees as he looks at his hypertensive patients is their average age. Most of them are past middle life. Of course the change occurs in younger people, though rarely, but even here the close examination of the patient simply confirms the primary statement because the structure of the body in such individuals shows the changes of age. So that one may say: "No matter how many years this man has lived, his organs, his arteries, are those of an elderly person." This question of the age incidence of the condition is of more significance than it may appear, because no explanation of it will hold unless it also explains the period of onset. In other words, if guanidine is the cause of it, why does guanidine only begin to act at about the age of fifty or sixty? Again, if it is caused by absorption from bad teeth, the bad teeth have been present in some people for many years, in others for a few years, but hypertension comes on in all at about the sixth decade.

One other feature of the condition, recently emphasized by Mortensen, is seen by the general physician better than the laboratory worker. It runs in families: it tends to be transmitted from parents to children. It may seem to the layman that such an observation implies no very great amount of perspicacity on the part of the physician. On the contrary, for various reasons, it is one of the most difficult of all conclusions to reach. Consider first that a physician himself lives only one lifetime; therefore he seldom has many opportunities to observe a disease both in parents and children, especially a condition the age onset of which in the children is past middle age. One other source of information is open to him — the statement of a patient about his parents' illnesses and causes of death. But such statements the physician has learned to distrust — partly because he cannot always trust the patient's statements about his own symptoms, and partly because the patients themselves are often frankly doubtful about the nature of the parents' diseases. Furthermore, for some reason which I am certainly unable to explain, the modern physician is almost totally impervious to the conclusions reached by present-day biology on the subject of heredity. However, just about enough time has begun to elapse — remember that we have been making routine blood-pressure examinations only for about twenty-five years — to begin to give us data, mostly from life-insurance actuarial sources — to cause us to acknowledge that the hereditary tendency is a primary factor in the condition. It is the only explanation which fits all the circumstances, because it is quite in accord with the latest conclusions of genetics to assume that there is laid down in the germ plasm a tendency for certain changes to occur in the somatic cells — such ones as the aorta, the arterial coats, and the capillary tufts of the kidneys — at a certain period in the individual's life history. Under this assumption we must define hypertension and arteriosclerosis simply as the biologic process of senescence.

The difficulty with the acceptance of such a conclusion is its finality. It is thoroughly pessimistic as regards amelioration by treatment and it stifles research. Refusing to accept it, earnest and astonishingly resourceful young men all over the world are hurling their spirits in attack upon the problem from the bacteriologic side, from the sides of chemistry, of pathology and physiology. There is one thing, however, which the earnest young men do not know, not because they are not sufficiently earnest, but because they are too young. They assume that because they find extensive organic changes in a body, that body is going to blow up unless the organic changes recede. But the compensatory and lasting-powers of a crippled body are often astonishing. Twenty years ago I bought my first blood-pressure apparatus, and, patients being somewhat scarce, I measured the blood-pressure of my father and mother. I was alarmed to find that in both cases it was far above the figures set down for the normal at their ages. Yet they have not only continued in the living world, but have continued their activities with a harrowing persistency. I see every day I stride the streets individual after individual whose blood-pressure I have read years ago and found to be definitely abnormal, walking about in full vigour of body and mind, though this is not to say that, taking large numbers of them, the mortality is not higher than in a group of people with lower blood-pressures.

So far as treatment is concerned, the only management which is of any value is so to regulate the general plan of life as to reduce the strain upon the brittle arterial system to the minimum. In this way life may be prolonged for years. The banking of the engines is to a certain extent a reasonable procedure. But this does not mean that all activity in the world should cease. To measure improvement by the reduction of the blood-pressure reading or to suppose such a thing possible is erroneous. On this point I speak with some assurance. For many years I examined applicants for life insurance. It was in general a dreary and monotonous business. But it had a few compensations. One was that I learned what conditions could be influenced by the treatment used by the medical profession and what conditions could not. It was nearly a daily experience for someone whom I had previously examined to be brought to me. At the former examination his blood-pressure had been found high. He announced that he had just taken a course of treatments and that his blood-pressure was now normal. But when I examined him, I found that his blood-pressure was just exactly at the same figure it had been at when I previously read it. Lest it be supposed that the treatments in question had been carried out by the ignorant therapeutists in my own obscure community, let me say that the treatments were undertaken in a great variety of medical centres, including New York, Baltimore, Chicago, Vienna, Berlin, Paris, and London. Not once in all my years of such observation have I seen a blood-pressure permanently reduced by any means whatever. (I except some of the recent results with liver extract in selected cases.)

What advice is proper and charitable to give on the subject? The most important thing to say is that the fluctuations in blood-pressure are not an index of the general physical condition. If the blood-pressure is up a little, it does not mean that the patient is worse than if it is down. It varies for many reasons. It is not a disease, but a physiological adjustment. On the whole I am inclined to say that after the age of fifty no one should ever allow his blood-pressure to be read, or, if it is read for a life-insurance examination, to be made known to him. The knowledge causes too much unhappiness. Certainly do not give up your work or your amusements, or, in the case of the female of the species, do not be daunted from running for governor, or entertaining the weekly bridge club. Life should be designed for living, for the fullest expression of joy and activity. It is better that it should flame out in the full heat of exuberance than that it should ebb and flow, watched by apprehensive eyes, with the bobbing of a column of mercury.

ANGINA PECTORIS, or pain in the heart, causes disability by the fact of the severe, frequently recurring pangs, which bring with them a sense of impending death. It is a frequent cause of sudden death. Death from what is usually put down as acute indigestion is almost invariably due to angina. I remember well that one of the first cases I ever attended was of this character. I was summoned at midnight to hurry across the street, to find my neighbour, a man of fifty-five years, dead on the floor. He had been perfectly well and had gone to a public dinner; on coming home he complained of pain in the pit of the stomach. Ten minutes later he died. On opening and examining his body we found not a single organ deranged, except that in one of the coronary arteries, which supply the heart itself with blood, was a clot the size of a kernel of wheat. The treatment of the seizures of angina is best accomplished by using drugs of the nitrite series — either nitroglycerin or amyl nitrite being the most commonly employed. It is one of the few diseases in which it is necessary to prohibit tobacco. Here again a general reduction in the high pressure of activity should be instituted. "Many a man's life has been saved by an attack of angina," William Osler once said. The attacks are usually brought on by unusual exertion.

METHODS OF EXAMINATION OF THE CARDIO-VASCULAR SYSTEM: In summarizing the means which have been developed in order to make a diagnosis of the condition of the heart and vessels, by far the most important single element is an analysis of the patient's statement of symptoms, or, in other words, his history. People nowadays are likely to get it into their heads that modern medicine clamps a machine on them and gets the most exact and circumstantial report from it. This doctrine entirely ignores the fact that the most delicate and sensitive recording device is the patient's own sensorium. We saw the same thing even more emphatically in the examination of the digestive apparatus. In the case of the heart and vessels we are in a better position than in the case of the organs of digestion because we have more reliable and more constantly informative objective methods of examination in order to check the patient's recital. But still that recital plays the major part. Of course, we are constantly aware that there are some objections to, or dangers in, this method. One is that the patient's statements are not always trustworthy — either he is one of those introspective or neurotic persons who exaggerate their symptoms, or, on the contrary, he is one of those stubborn self-confident individuals who minimize or scorn their symptoms. The answer to this is to point out that we said an *analysis* of the patient's statement. The physician must be familiar with the physiology and the pathologic physiology of the circulation. Another legitimate objection is that in the organs of circulation certain pathologic conditions may develop so insidiously as to be unnoticeable — a murmur may develop or the pressure in the arteries increase so subtly that the person affected is entirely unaware. This is, of course, true, but on the whole it is the best plan. Nature is here the wise and compassionate friend. It is unfortunate that so many physicians who happen to discover one of these things in the course of a routine examination cannot imitate her kindness and her compassion — and above all her silence. Nothing in the way of treatment can be done for such conditions, and if they go on to cardiac failure, when beneficial treatment can be instituted, the earliest signs of the failure will be the symptoms which the patient himself recognizes.

Recently I saw in one of the pastoral letters which H. Addington Bruce, M.D., distributes every so often in the lay press, a statement to the effect that he had heard a prominent physician say that golf was a good exercise for elderly men, but that every man over fifty should have a careful examination of his heart before he undertook a season of play. Dr. Bruce did not think that the prominent physician went far enough and advised that the age of forty should be set for the proper limit of yearly cardiac examination. No more pernicious and meddlesome doctrine is current to-day than that of which such a statement is an example. Its most dangerous feature is its plausibility. It does seem logical to a business man untrained in medical view-points or habit of mind that he should be examined once or twice a year to see "if everything is in good running order." But a very superficial analysis of the matter will show that its integrity depends upon two assumptions — one, that the disease be absolutely symptomless, that the examination by a physician is conducted with the help of instruments more delicate and more accurate than the patient's own sensations, and the other is that when the possible defects are found, they can be successfully remedied. Both of these assumptions, in my experience, are false.

Let us analyse this matter of the examination of the golfer's heart. It is my belief that any defect in the physiologic soundness of the golfer's circulatory system will be known to the golfer by the symptoms which are produced. And remember it is only the physiologic (not anatomic) defects in the circulatory system that can be helped by treatment. If the golfer is not embarrassed by shortness of breath, if he experiences only a mild pleasurable fatigue after his game, if his limbs feel tired but cleaned, we may assert with a confidence which no instrument can gainsay that his circulation is in good condition and that his exercise is beneficial. It is quite true that with means at hand the examiner can find in many forty- and fifty-year-old men evidences of anatomical change which are the precursors of degenerative changes in the circulatory system. He may find a systolic murmur at the apex, or a blood-pressure of 150. When a man dies at seventy of cerebral apoplexy, the changes in his arteries which brought the condition on began to occur twenty or thirty years before. What is the physician who has made these findings to do? If he is ignorant and unwise, he will tell the patient that there is something the matter with his heart or arteries, and the patient is thereupon frightened nearly to death, gives up his golf, settles into a life of semi-invalidism, and prepares for the end. He is changed from a happy and useful companion to a neurotic invalid. If the physician is not quite so unwise or so ignorant, he may tell the patient that there is a little something the matter with his heart, but that the golfing exercise will be good for it. The result is that the golfer continues to be a golfer, with the exhilarating addition that he wonders all through his game whether or not he is going to drop dead on the eighteenth green.

The point is worth labouring a little further. There are all over this country now institutions whose sole business it is to make routine physical examinations on supposedly healthy persons once or twice a year. There is growing up a strong wave of opinion in favour of this plan, and among the most enthusiastic adherents of it are the members of my own profession. From that opinion I most strongly dissent. If I am asked: "What, don't you believe that a person should be examined once a year?" my reply is quite simple — "No, I do not." I have seen the plan in operation and I have seen practically nothing result but grief and unhappiness. The number of people who supposed themselves well and who were symptomless, and who found on examination a condition of disease which could be materially remedied — the number of people whose lives were lengthened — was so small as entirely to be minimized in the face of the dead load of meaningless sorrow entailed. What usually happens is this: most of the patrons of such a system are men; most of them have considerable financial responsibility, and most people who have considerable financial responsibility are no longer young. Therefore a middle-aged man is the usual victim. In the great majority of cases if such men have anything to be found wrong with them, it is a slight defect of the heart, some kidney change, and a beginning of hardening of the arteries, or hypertension. There is "a splintering of the Q R S wave in the electrocardiogram, an accentuated aortic, a pressure of 170 over 95, a faint trace of albumen, and an increase in the blood uric acid." This report is handed to a man who believes he is in good health. He looks up things in an encyclopædia or medical book and decides he has received his death-sentence. He goes on a diet to reduce his uric acid, is denied whisky, gin, tobacco, and venery, in fact anything which might lighten the gloom. Not one of his abstentions changes the tissues of his body. If he had not had the examination, he might have lived twenty-five years without a symptom. He has been turned from a happy, self-contented member of society into a morose, apprehensive hypochondriac. This scene has become so frequent a drama that in my own circles there is a phrase for it — "One of those damnfool health extension cases."

To balance this it is acknowledged that some cases of symptomless diabetes and early tuberculosis of which the owner is unaware are discovered. Also latent syphilis may be discovered, though the owner is usually not unaware. I know of no other common diseases likely to be detected by routine examination.

It is true that the public is demanding these examinations, and presumptively under those circumstances they must be made. I know of nothing in medicine which requires so much wisdom and tact as the method of formulating the report of such examinations to the patient. Personally, in most cases, I believe the inevitable and disagreeable feature should be modified or suppressed. Here I collide with Dr. Richard Cabot of Boston. Dr. Cabot maintains that the doctor must never tell a lie. He has advocated that every patient should always be told the whole truth no matter how devastating or tragic it may be. Twenty years ago, when I first heard this doctrine, it made a deep impression on me. The years have brought me, if not wisdom, at least dissent. I see it now as nothing but the New England conscience crying in the wilderness. You remember when a witch was hanged at Salem, she was preceded on her march to the gallows by a Puritan pastor who admonished her to rejoice because she was being hanged, as it would be so beneficial for her soul. Dr. Cabot would have us say to a patient: "You have cancer of the stomach and are going to die," adding: "I tell you this frankly because I think the knowledge will strengthen your character." To be perfectly just to him, his main argument devolves upon the fact that if the physician does not tell a lie, it will have a good effect upon the relatives; that later if a physician tells one of them he is going to live, he will be believed. Still I am not so sure about all this. I am willing to let the future take care of itself. I sometimes believe that deep in his heart Dr. Cabot believes in absolute right and wrong. Myself I am an ethical pragmatist.

Furthermore we doctors do not always know the truth. Medicine is an art, not a science: mistakes will occur. I recall one case of a man who was told he had a sarcoma of the mediastinum and that he would die in a year. He sold out his business and prepared with such fortitude as he could for the end. That was twelve years ago and he still lives. Coleridge on one occasion, you remember, demanded in a loud voice the whole truth, and Charles Lamb replied that he did not happen to have it with him.

After the patient's statements the next most important means of examination are the physician's senses — hearing, seeing, and feeling. The general appearance of the patient, how he breathes after exercise, whether his ankles are swollen, the rate and regularity of his pulse, the hardening of the arteries, the sounds of the heart — these, with the history, make up ninety per cent of the valuable data.

The reading of the blood-pressure as has been described above is next in importance. The exact size of the heart and aorta can only be made out by the X-ray.

CHAPTER VII

NUTRITION

After the foodstuffs have been converted by the digestive juices, after they have been absorbed by the blood or lymph, after the oxygen from the air has likewise been absorbed into the blood, after the blood, driven by the heart, has been carried in the arteries to all parts of the body, these materials are utilized for the production of energy, for the production of heat, and for the replacement of broken-down cells. This crucial process is called nutrition or metabolism.

The most convenient approach to an understanding of metabolism will be to examine the fate of the different sorts of foods. In foodstuffs are six kinds of chemical ingredients — carbohydrates, proteins, fats, water, inorganic salts, and vitamins.

Carbohydrates, also called starches, may be exemplified first by *sugar*, which is pure carbohydrate (unmixed with protein or fat); by the principal proportion of *vegetables* and *fruits* (though these contain all the other food principles); by a large part of *bread*, and other grains such as *oatmeal*, *cornmeal*, and *rice;* and by *milk*.

Proteins are represented by *egg-white*, which is pure protein, and by the *meats* (mixed with fat and salts), *fish*, *game*, and *oysters;* there are also vegetable proteins, of which such vegetables as *peas* and *beans* contain a high proportion; proteins are also present in nuts.

Fats are represented by *butter* as the pure example of fat in daily use, by the *fat part of meats*, by *cream*, by the *fat in nuts*, and to a small extent by nearly all vegetables, particularly *asparagus*, *cocoa*, and *alligator pear*.

Water is contained in all food substances combined or free. Some vegetables contain as high as 90%. Milk contains 87%, eggs 65%, and meats about 50%.

Inorganic salts. The diet must contain suitable salts of the following elements — calcium, magnesium, sodium, potassium, chlorine, phosphorus, sulphur, and iodine. Any average diet will. In some places, as the region of the Great Lakes in this country, and in Switzerland, iodine salts are very deficient in the water and soil and are now deliberately added to the diet to prevent the development of goitre. Calcium is a constituent of the bones; sodium, potassium, and iron salts find their way into the blood.

Vitamins are found in cream, butter, egg-yolk, cod-liver oil (Fat Soluble A), in yeast, milk, and rice bran (Water Soluble B), and in orange-juice, tomatoes, potatoes, lemon- and lime-juice and green vegetables (Water Soluble C).

Each of these six principles has a different fate after entering the body. Taking the carbohydrates, fats, and proteins, we may say that in general the carbohydrates are used entirely for fuel, the proteins largely for tissue replacement; and the fats occupy an intermediary position, sometimes being used for fuel, sometimes for tissue, but when used for tissue, they are really storage energy, and are the first tissues used when the body needs fuel and no food is available.

Carbohydrates, proteins, and fats, however, all share in heat production. In fact the measurement of heat production is the only method we have of measuring the value of a given quantity of food. The unit of measurement of heat production is the calorie. A calorie is a definite amount of heat, just as an inch is a definite amount of length. It is the amount of heat required to raise a kilogram of water one degree centigrade (or a pound of water eight degrees Fahrenheit). It would be interesting to show you the apparatus used to determine the caloric value of different foodstuffs. It is a large chamber capable of admitting the entire animal to be studied — man or dog; water-coils surround it so that all the heat generated by that body in a given time may be measured, and the amount of oxygen it uses and the amount of carbon dioxide it gives off can be determined. It is called a respiration calorimeter and is extremely accurate; for instance, we know that we can control the amount of electricity necessary to produce a definite amount of heat when sparked between two terminals; when the spark is produced in the respiration calorimeter, an independent observer who does not know the amount of heat the spark is set to produce can calculate it with an error of only one one-hundredth of one per cent. When you hear someone glibly discoursing of the number of calories in his diet, remember that all the data he is working on were determined by thousands of painstaking experiments with this very delicate instrument.

With the respiration calorimeter we are able to determine the caloric requirement of a human being. That is, we are able to measure the number of calories he will need to maintain life without losing weight. This requirement varies with three factors — the individual's age, the weight, and the amount of activity — whether the body is at rest, at moderate exercise, or heavy work. The younger the individual, the higher the caloric requirement — i.e., the more nutrition is needed: at the age of one year, 44 calories are needed a day per pound of body-weight; at the age of eighty, 11 calories are needed per pound of body-weight; at the age of thirty to fifty, from 18 to 15 calories are needed a day per pound of body-weight. At rest in bed an adult needs 11 calories per pound per day, at light exercise 20 calories per pound per day are used (less than one calorie per pound per hour), and at very heavy laborious exercise, such as a football player in a hard game or a lumber-jack felling trees exerts, 38 calories per pound per day are needed. Summing these up, we say that an average adult human body of 150 pounds needs about 1600 calories at rest, about 2500 calories at ordinary activity, and about 6000 at very hard work.

It is important to remember that under normal conditions of health we have a very delicate regulator of the requirements of the body in the appetite. In illness, particularly during fever, this indicator may not allow the body enough; as age advances, it is inclined to deceive us into believing that we need more than we do. But on the whole it is not necessary in health for anyone to worry about the calculation of his diets, but he may turn them over to this very efficient monitor — the appetite.

Knowing, then, the requirements in calories of the body under different conditions, the next set of data which we shall naturally wish to know is the number of calories in a given amount of each kind of food. This has been worked out by scientists in grammes, and because the gramme is unfamiliar to them, American patients are often confused; a gramme is about one thirty-second (1/32) of an ounce, or one three-hundred-and-seventy-sixth (1/376) of a pound. The three foodstuffs — carbohydrates, protein, and fat

— have been calculated very accurately to several decimal places as to their caloric value, but for practical purposes we may say that:

Carbohydrate yields 4 calories per gramme, or 128 calories per ounce.
Fat yields 9 calories per gramme, or 288 calories per ounce.
Protein yields 4 calories per gramme, or 128 calories per ounce.

From these figures, and with a table showing the composition of any given food, it is easy to calculate the value of a given amount of that food. Some examples may prove helpful to those under the necessity of calculating diets on a strict basis. Let us choose an egg. First we find that eggs weigh varying amounts. I have found three eggs in my ice-box that weigh respectively 70 grammes, 50 grammes, and 20 grammes. An egg contains on the average about 13% of protein, about 10% of fat, and no carbohydrate. An egg weighing 50 grammes, then, contains 6.5 grammes of protein and 5 grammes of fat. The protein will yield about 4 calories per gramme and the fat 9 calories per gramme. In this 50-gramme egg there are therefore 26 calories from the protein and 45 calories from the fat — a total of 71 calories. A lump of sugar which I may put in my coffee weighs half an ounce, or 15 grammes. It contains nothing but carbohydrate; therefore it yields 4 calories per gramme, or 60 calories. A slice of white bread which I have just cut weighs 1 ounce: it contains 9% protein, 1.6% fat, and 53% carbohydrate; the rest is water and salts. Therefore the slice of bread (1 ounce, or 32 grammes) has:

About 3 grammes of protein, which yields 4 calories per gramme (3 × 4) = 12 calories.
About 1/2 gramme of fat, which yields 9 calories (1/2 × 9) = 4.5 calories.
About 17 grammes of carbohydrate, which yields 4 calories per gramme (17 × 4) = 68 calories.
Total caloric value of 1 slice bread = 84.5 calories.

An easy system to remember is that, with curious regularity, the average generous helping of the common articles of food amounts roughly to 100 calories. A table is put in to show this:

Amounts of Food Which Contain 100 Calories

	Protein in Grm.
Milk, a glass (5 oz.)	5.
Cream, 16 per cent (2 oz.)	1.5
Buttermilk, one and one-half glasses (9.5 oz.)	8.
Koumiss, one glass (7 oz.)	5.
Whey, two glasses (13 oz.)	3.5
Eggs, one and one-half	10.
Whites of eggs, 6	24.
Yolks of eggs, 2	4.5
Oatmeal, one and one-half servings (5.5 oz.)	4.25
Boiled rice, ordinary cereal dish (3 oz.)	2.5
Hominy, large serving (4.2 oz.)	2.5
White bread, home-made, one thick slice (1.25 oz.)	3.2
One small Vienna roll (1.25 oz.)	3.2
Butter, one pat (1.5 oz.)	0.0
Sugar, three teaspoonfuls, one and one-half lumps (0.8 oz.)	0.0
Oil, one-third ounce	0.0
Cod-fish, two servings (5 oz.)	23.
Halibut steaks, one serving (2.8 oz.)	15.
Mackerel, Spanish, one serving (2 oz.)	12.2
Shad, one serving (2.1 oz.)	11.2
Salmon, small serving (1.5 oz.)	7.3
Oysters, 12	12.
Roast beef, ordinary serving (1.8 oz.)	10.
Small sirloin steak (1.4 oz.)	7.5
Leg of lamb or mutton, ordinary serving (1.8 oz.)	10.
Lamb chop, one, small (1 oz.)	6.
Bacon, small serving, medium fat (0.5 oz.)	1.5
Chicken, broiler, edible portion, large serving (3.2 oz.)	19.
Turkey, large serving (1.2 oz.)	7.
Potato, baked, one, good size (3 oz.)	3.75
Potato, sweet, baked, one-half average potato (1.7 oz.)	1.5
String beans, five servings (16.66 oz.)	3.75
Spinach, two ordinary servings (6.1 oz.)	3.7
Peas, green, one serving (3 oz.)	5.7
American or Swiss cheese, 1.5 cubic ounces (0.75 oz.)	6.
One baked apple, 3.3 ounces	6.5

The value of foods for tissue replacement is not so easy to determine. We cannot accurately, for instance, tell when a cell from the lining of the intestine is dead, cast off, and replaced by another cell; and we cannot tell how much that cell or numbers of them represent in terms of food amounts. Here too the general appetite instinct of the animal is an accurate and safe guide.

To show, however, with what care the whole science of nutrition has been studied, I may recall that Voit in 1866 collected the shed hair and epidermis from a dog for 565 days and found that the average daily loss amounted to .18 grammes of nitrogen. Moleschott cut the nails and hair of several men once a month. The daily outgrowth of hair was 0.20 grammes, with 0.029 grammes of nitrogen, and of nail substance 0.005 grammes, with 0.0007 grammes of nitrogen.

A word of grateful remembrance should be inserted here. The apparatus with which the fundamental work on nutrition was done was given to two German physiologists by King Maximilian II of Bavaria. The cost of it was considerable. Voit, one of the men, has described the delight which he and his colleague experienced when their wonderful machine began to tell its tale of the life processes. Without the enlightened benefaction of Maximilian this knowledge would have been lost perhaps permanently. I make a deliberate reference to him because this book is intended for lay readers, some of whom may have funds which they would like to use for the benefit of their fellow human beings. I know of no way to use them so effectively as by the endowment of medical research. Certainly there is nothing which is likely to yield results beneficial to so large a number of people. Think for a moment of insulin, the magical substance recently discovered for the treatment of diabetes. It benefits rich and poor, just and unjust, white and black, Methodist and Catholic. Ten years ago a rich man whose little daughter had diabetes could not have bought at any price anything for her except advice about an almost starvation diet. With the discovery of insulin he is just as well off as the poor man. The sort of knowledge acquired in the fundamental work on nutrition could not have come from an accidental discovery, from a bit of fortuitous inspiration. It was the result of carefully planned experiment with costly apparatus. There are thousands of pieces of work to-day waiting for solution upon equipment which is too expensive for many a laboratory worker who has the inspiration and the ability to accomplish the research, but not the money to purchase the equipment.

The experience has been repeated many times in the history of medical discovery. When the Rockefeller Foundation for medical research was begun, people were sceptical. The Foundation started out to find a cure for epidemic meningitis; people said: "You cannot find a cure like that just by experimenting: it takes a fortunate accident." Yet by hard work alone, and repeated experiments, they did find a cure for meningitis. Unless Mr. Rockefeller had furnished the money, the world would probably not have a cure for meningitis. Mr. and Mrs. McCormick, of Chicago, lost a child with scarlet fever; they founded a Memorial Institute for the study of infectious diseases and stipulated that an endeavour be made to discover the cause and a cure for scarlet fever. After twenty years of work Dr. George Dick and his wife, working in the Institute endowed by the McCormicks, have actually succeeded in proving the cause of scarlet fever to be a form of streptococcus. They have also prepared an effective serum for treatment, and one for prevention, as well as demonstrating the means of detecting those individuals who are not immune to scarlet fever and who, therefore, need the preventive serum. All these discoveries were the result of hard work in a properly equipped laboratory with facilities for research. The latter could not have been obtained without money.

This sketch of the science of nutrition is very incomplete. No division of medicine has been so thoroughly and mathematically worked out. I have told nothing of starvation experiments, of feeding experiments in which one kind of food only was given over a period of time. of the observations on growth in young animals when fed different kinds of food, of the studies in heat regulation, and of the metabolism in fever. It is a fascinating story, full of incidents as dramatic and absorbing as the panorama of the French Revolution, and fraught with far more significance to any individual person among my readers.

Summarizing what we have learned about nutrition: the body utilizes six kinds of foodstuffs — carbohydrates, proteins, fats, water, mineral salts, and vitamins; these substances are burned in the body and used to replace tissue waste; when burned, the carbohydrates, proteins, and fats yield a certain definite and measurable amount of heat energy; the unit of measurement is the calorie; all common foods have been analysed to show the relative content of these food elements.

DISEASES OF NUTRITION

DIABETES mellitus is the disorder of sugar and starch nutrition. Patients with this disease and their relatives usually experience considerable difficulty in understanding its nature. Their chief trouble, because the amount of sugar in the urine is such a good guide to its severity and treatment, and therefore the examination of the urine is so frequently repeated, also because the act of urination is so disturbed in the early and untreated cases, is that they get the idea that it is a disease of the kidneys. Nothing could be further from the fact. But the medical profession itself for long was under similar misapprehensions. Aretæus the Cappadocian, who lived about the first decade of the Christian era, and who first described it, conceived it as a "melting of the flesh, which flowed away in the urine." This description emphasizes two of the cardinal symptoms of diabetes — emaciation and increased flow of urine — and if loss of weight and frequent urination are ever complained of in your hearing, your acquaintance should certainly be advised to consult a physician. The discovery that diabetics' urine contains sugar was made many years after Aretæus. Just where the fault lay was a mystery. The liver, the intestines, and the blood were all impugned. The story is told that Naunyn, the famous Strassburg physician, in about 1890, was walking across a bridge connecting one wing of his hospital to another when he happened to observe two packs of dogs in the bricked courtyard below, separated from each other by a fence. The professor of physiology had been performing a set of experiments in digestion, and to further these he had removed the pancreas from some of the dogs. In order to avoid confusion he had segregated the dogs from which the pancreas had been extirpated from the others. The day was warm and Naunyn, leaning on the railing in one of those moods which come to scientists as well as to poets, when the intellect and the spirit are both bright and clear, noticed that swarms of flies gathered on the urine of the dogs whose pancreas had been excised and not upon the urine of the dogs unoperated upon. He went himself and collected some of the urine which the flies swarmed on and tested it for sugar. Sugar proved to be present: the dogs had diabetes. Naunyn stalked into the laboratory of physiology —

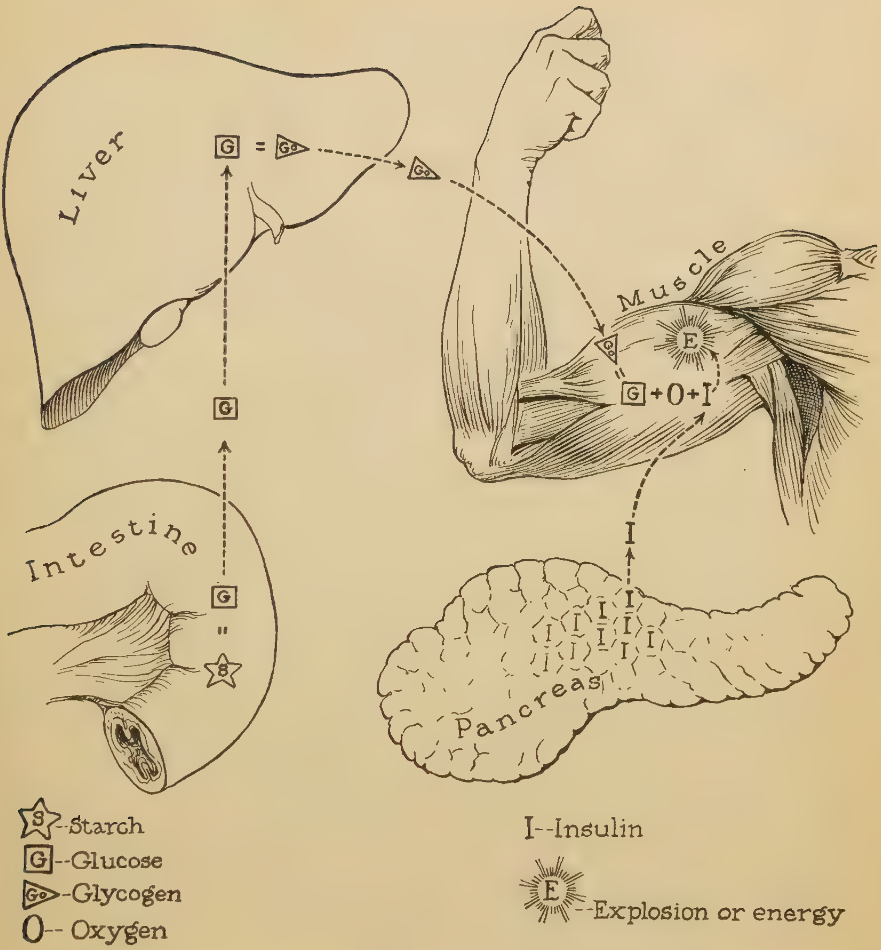

Liver
G = Go
G
Intestine
G
S
Muscle
E
G+O+I
I
Pancreas
S--Starch
G--Glucose
Go--Glycogen
O-- Oxygen
I--Insulin
E--Explosion or energy

FIGURE 48

Diagram of carbohydrate nutrition. Start in the lower left-hand corner. Here the starch after being swallowed is converted to glucose in the intestines, absorbed and carried by the blood-stream to the liver, where it is converted into glycogen and stored as such. When a muscle contracts, it needs fuel, and the glycogen is carried by a blood-vessel from the liver to the muscle, converted again into glucose, mixed with oxygen which comes from the lungs, and "fired" by insulin which comes from the islets of Langerhans in the pancreas, producing energy. The only difference between this normal process and the diabetic's is that the diabetic has no insulin. Therefore in the diabetic the glucose accumulates in the blood and passes off as sugar in the urine.

"What have you done to those dogs in the courtyard?" he demanded of the professor of physiology.

"I have removed the pancreas," was the reply.

"Then," cried Naunyn, "lack of a pancreas causes diabetes."

Shortly afterwards it was shown that if the duct of the pancreas, which conveys the digestive juices to the intestines, were cut and the pancreatic digestive fluid allowed to flow outside the body, no sugar appeared in the urine. Therefore the role which the pancreas plays in the causation of diabetes must be from the elaboration of a secretion which is poured into the blood-stream, not into the intestines. In a cut section of the pancreas a number of nests of cells, differing from other pancreatic tissue, were seen by Paul Langerhans in 1869. This finding was amalgamated with Naunyn's later observation and the islets of Langerhans in some diabetic cases were found to be destroyed. Just in our own day extracts of these islet-of-Langerhans tissues, injected hypodermically into diabetic patients, have resulted in the ultimate triumph over the disease.

What, then, does happen in diabetes? Normally the nutrition of starches and sugars begins with their being turned, by the digestive juices, into glucose, chemically a very simple sugar. From the intestines glucose is absorbed and carried to the liver. Here it is converted into a form of carbohydrate, glycogen, or animal starch, found in animal livers. This is apparently the only form of starch which an animal can keep in storage. When a muscle contracts and needs energy to do it, the energy comes almost entirely from glucose. To supply this the liver sends out glycogen, which is reconverted either in the liver or in the muscle to glucose, and when the muscle contracts, the glucose is burnt, or oxidized — it unites with oxygen from the blood — producing heat and energy, and reducing the glucose molecule to water, carbon dioxide, and a little lactic acid. The spark which causes the glucose to burn — i.e., to unite with the oxygen — is insulin, the secretion from the islets of Langerhans in the pancreas. When the muscle contracts, this insulin is also called for from the pancreas, just as the glycogen is called for from the liver.

In diabetes every detail of this procedure is the same, except that, the islets of Langerhans being more or less diseased, there is either little or no insulin. (They are probably never completely destroyed.) Thus the glucose gets to the muscle, is not burned, and accumulates in the blood. The kidney is very sensitive to the presence of glucose in the blood above the normal amount — about .09 mg. per 100 cc. Therefore, when the glucose is increased in the blood, the kidney removes it from the blood along with enough fluid to dissolve it in the urine. That is why the urine is involved at all. That is why the kidneys get a bad name in diabetes. That is why untreated diabetics are always thirsty.

Woodyatt, a brilliant living investigator of diabetes, has compared the condition to a gasoline engine. In order to have the cylinder of the gasoline engine pump (in order to have a muscle contract) gasoline must be brought from the tank (glycogen — glucose — must be brought from the liver) and mixed with air in the carburettor (the glucose mixed with air from the lungs via the blood), but for an explosion the spark-plug must produce a spark (the pancreas must produce insulin). If the spark-plugs are dirty (if the islets of Langerhans are diseased), the combustion is incomplete and black smoke comes out of the exhaust (glucose comes out in the urine).

The treatment of diabetes is perfectly logical from an understanding of its nature. If the diabetic body cannot burn as much starch as a normal body, the amount of starch in the diet must be cut down. Fortunately, now, through the discoveries of Banting, Best, McLeod, and Campbell, who found a method of isolating the secretion of the islets of Langerhans, which they called insulin, we are able also to supply the deficiency of that substance. Diet is, however, always still the mainstay of treatment, and with every diabetic, proper dietary adjustment must be maintained.

There are several pieces of advice which every diabetic should take to heart. First, the patient should realize that the medical profession knows *all* about diabetes. It knows all about the cause, the nature, and the treatment of it. As the treatment may be very complex, the patient should always put himself or herself into the hands of a member of the regular profession. With certain other diseases it is of no real importance whether a regular practitioner, a chiropractor, a Christian Scientist, or an Indian medicine-man is called in. But in diabetes it is nothing short of a crime not to employ a regular physician, because, over this disease at least, we can say with absolute confidence that we have complete mastery.

Second, the patient must become acquainted with the principles and the details of the treatment. He must learn to examine his own urine for sugar. This is done by using a testing fluid — Benedict's solution or Haines' solution, which can be purchased at any drug-store. An alcohol lamp or gas flame will be needed, also a test-tube and a medicine-dropper. The Benedict's solution is put in the tube and boiled over the flame. A few drops of urine are then added and the solution boiled again. If a reddish or yellowish or greenish cloud (a precipitate) forms, glucose is present. Besides this the patient must learn the composition of all the foodstuffs — the amount of carbohydrates, fats, and proteins each contains. A scale must be obtained and the food to be eaten weighed, at least until an estimation by the eye of the weight of the regularly eaten articles is possible. There are a number of books written especially for diabetics in which complete explanations of all these things are given. I can heartily recommend as one of these Elliott Joslin's *Diabetic Manual* (Lea & Febiger).

Third, if insulin is to be used, it will in the present state of our knowledge have to be given by hypodermic, as taken by mouth it is immediately destroyed by the stomach juices. The patient, of course, must learn the technic of hypodermic injections and give them to himself. The syringe should be a glass one: that is the only kind which can effectively be sterilized. The needle should be a No. 26 gauge. The syringe and needle should be boiled for sterilization purposes before every injection. For travelling a Sterno tin is a convenient method of carrying a fire. The skin should be wiped with alcohol before injection.

Fourth, treatment is carried on to avoid complications. Patients frequently say to a physician: "You say that a part of my food is not burned, and flows off in the urine in the form of glucose. Very well, why can't I just eat that much more food and let the excess go." The answer is that, with the carbohydrate metabolism disturbed, there inevitably follow disturbances in the metabolism of other foodstuffs, particularly fats. The fats also furnish fuel, and if they are to burn, a certain amount of carbohydrate combustion is also necessary. If this does not occur, they burn incompletely and chemical bodies which represent partial

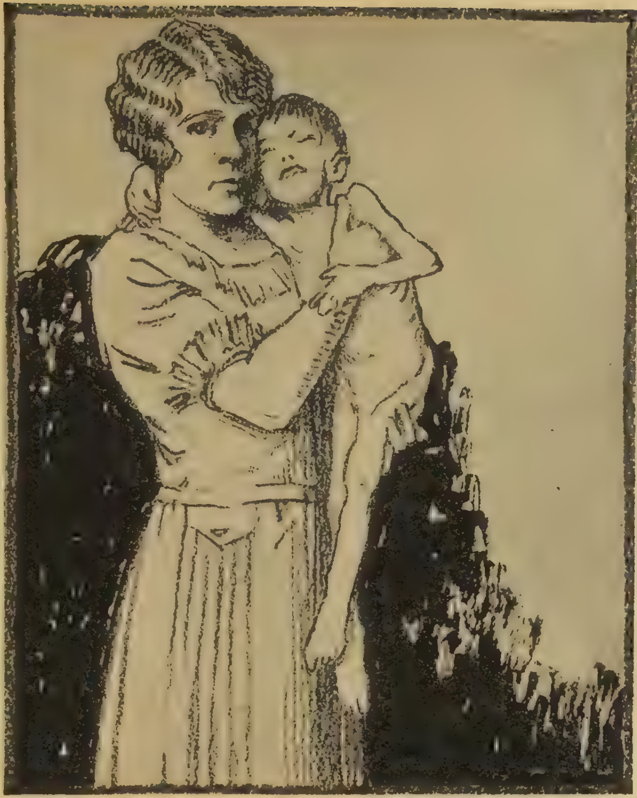


FIGURE 49

Child with severe diabetes. Before taking insulin.

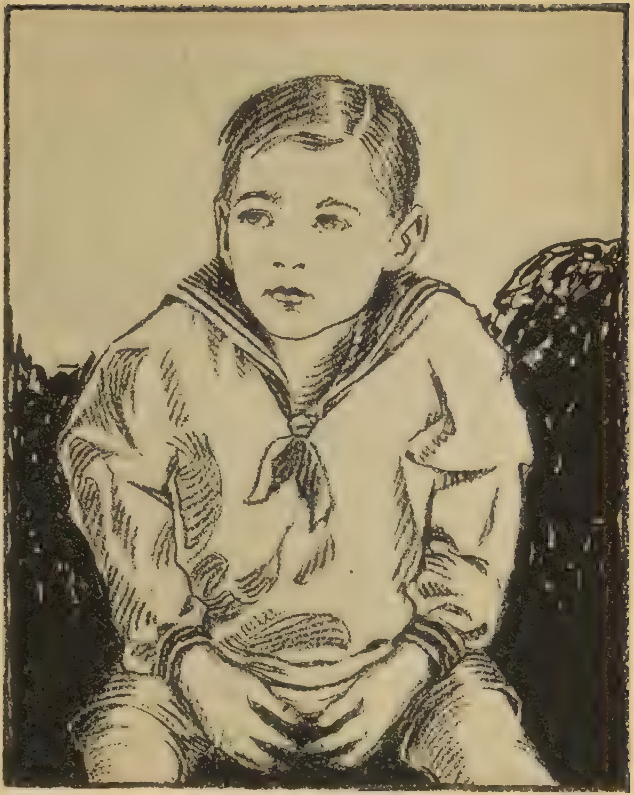


FIGURE 50

Same child as Figure 49. After taking insulin three months.

stages of the break-down of the fats accumulate. These are fatty acids and lead to the most fatal of the complications of diabetes — acidosis and diabetic coma.

Fifth, patients often make one serious mistake in calculating diets. They calculate the amount of starch they can utilize and then eat it in the form of very simple sugars or starches, such as candy, ice-cream, bread, etc. These may cause glucose to appear in the urine even if the dietary calculation is carefully made. More complex forms of starch should be used, such as green vegetables. This is because the simple sugars and starches are very quickly converted into glucose by the digestive apparatus and carried to the liver in such quantity as to overtax its power to convert them quickly into glycogen. This may happen even in health — alimentary glycosuria. Vegetables, particularly green vegetables, cauliflower, carrots, etc., are the best form of starch for the diabetic.

Sixth, the treatment must be continued for life.

Seventh, waste no pity on yourself. Diabetes is the pleasantest of all the chronic diseases. There is no pain, and man has written on its face: "This disease I have conquered."

OBESITY: Excessive storage of fat may arise from several causes. Certain cases are undoubtedly due to disturbances of the ductless glands: the fat boy in *Pickwick* was probably a subject of insufficiency of the pituitary. And cases of obesity from overweight due to myxœdema or thyroid insufficiency are frequently seen. Again, at that period in life when the ovaries cease to function it is notable that women take on weight and it is often unevenly distributed. In the more gradual change of life which falls to the male's part a similar increase is noted. There is an old English couplet which contains a great deal of nutritional and endocrinic wisdom:

When to the age of forty they come,
Men run to belly and women to bum.

(*Bum* is apparently Warwickshire slang for the gluteal regions. It occurs in *Midsummer Night's Dream*, Act II, Scene i, when Puck says:

The wisest aunt, telling the saddest tale,
Sometime for three-foot stool mistaketh me,
Then slip I from her *bum*, down topples she,
And "Tailor" cries, and falls into a cough.

The word "tailor" has puzzled the poor commentators nearly frantic. They all quote Dr. Johnson, who thought he could remember to have heard the expression "Tailor" used when a person's seat slipped from under him. No one has ever had any better explanation, nor has it occurred to anyone that perhaps the real word was "Tailer," which might make some sense.

The word "bum" was utterly unfamiliar to me until I heard the verse I have quoted. But only last year I heard a Virginian speak of a little girl's being spanked on the "bummy.")

Other cases of obesity are equally plainly due to a bodily disposition. That type of person described in Part I as of a lateral build has with that lateral build a tendency to small lungs, good appetite, and overweight just as surely as the characters "vermilion" and "miniature," or "brown" and "speck," are grouped together as hereditary characters and transmitted together in *Drosophila*. As a rule these people do not grossly overeat, in spite of their appearance, though usually they do under-exercise.

Strouse has recently published a series of studies on "The Metabolism of Obesity" (*Archives of Internal Medicine* Vol. 34 and Vol. 36; 1924 and 1925) which tend to indicate that the obesity of the constitutionally fat person is not his fault. There is some other factor at play than the mere mathematical question of the intake of food, balanced by the dissipation of energy by exercise, work, or activity. He selected a patient, a girl of 30 years, weighing 173 pounds. She was thoroughly familiar with the computation of dietetic figures, because her mother had been a diabetic for years, and this patient calculated and prepared the diabetic mother's meals. The experiment was therefore accurately conducted. For six months this patient lived on a diet which was one fourth of her calculated food requirements; at the same time she went through systematic and vigorous exercises. At the end of this period she weighed only one ounce less than when she began.

So there is real justification for the wail of these people that they cannot help being fat, that they really eat less than other people. They should be pitied rather than censured. Strouse's experiments tended to show that, contrary to general belief, starches did not fatten them so much as fat. They seem to have a peculiar tendency to store, not burn, the fat which is eaten.

The remaining group is composed of people who ask doctors at dinner tables: "Is alligator pear fattening?" Anyone who will take the trouble to read over the first part of this chapter must see how absolutely foolish such a question is. It leaves out all the factors of the problem. It does not tell us how much alligator pear there is, it does not make any record of the amount of exercise or the caloric requirement of the consumer of the alligator pears. Every food that has any food-value at all is fattening if taken in large enough quantities. I shall not soon erase from the tablets of memory the picture of a middle-aged woman going about at a certain summer resort eating lemon after lemon because they were "thinning."

To reduce weight in patients of this class is a mathematical problem, which has an unknown X factor, that factor being human nature. Reducing weight means to eat less, particularly of those foods, starches and fats, which readily turn into fat, and to work or exercise more. It is a very simple equation; the only reason it is not more successful is that human nature is easily tempted and that people get into the notion that if they diet for a while, that is all that is necessary. The treatment of overweight, like the treatment of any metabolic disease, is a life-long job. Remember, you armies of easily discouraged dieters, the words of an eminent physiologist — "Fat is wet gunpowder." It *will* burn after there is nothing else to consume, but it must be dried.

Here is a good list of menus for anyone who wishes to undertake a rapid reduction cure.

First Week

Breakfast	*Dinner*	*Supper*
1 egg (soft boiled)	1 egg (soft boiled)	1 egg (soft boiled)
1 dish tomatoes	2 oz. 5% vegetable	1 dish 5% vegetable
1 cup broth	2 oz. 5% vegetable	1 dish 5% vegetable
1 cup coffee (no milk or sugar)	1 cup broth	1 cup broth
	No milk; no sugar; no salt	

SECOND WEEK

Breakfast	*Dinner*	*Supper*
1 egg (soft boiled)	2 oz. meat or fish	1 oz. meat (lean)
1 dish tomatoes	3 oz. 5% vegetable	1 egg (soft boiled)
1 dish 5% vegetable	2 oz. 5% vegetable	3 oz. 5% vegetable
1 cup broth	1 cup broth	3 oz. 5% vegetable
1 Graham gem (no butter)	1 egg (soft boiled)	1 Graham gem
		1 cup broth

THIRD WEEK

Breakfast	*Dinner*	*Supper*
2 eggs	⅙ oz. butter	⅕ oz. butter
6 oz. broth	2 oz. meat	1 oz. meat
4 oz. 5% vegetable	3 oz. 5% vegetable	1 egg
1 slice bread	6 oz. broth	3 oz. 5% vegetable
	2 oz. 5% vegetable	1 slice bread
	1 slice bread	

FOURTH WEEK

Breakfast	*Dinner*	*Supper*
3 oz. cream	⅓ oz. butter	⅓ oz. butter
⅓ oz. butter	2 oz. meat	2 oz. meat
2 eggs	3 oz. 10% vegetable	1 egg
3 oz. 5% vegetable	6 oz. broth	3 oz. 5% vegetable
½ cup oat flake	2 oz. 5% vegetable	2 oz. 10% vegetable
1 slice bread	1 slice bread	1 slice bread

5% *Vegetables*

- lettuce
- celery
- endive
- spinach
- sauerkraut
- string beans
- asparagus
- chard
- cauliflower
- tomatoes
- egg plant
- radishes
- cabbage

10% *Vegetables*

- onions
- squash
- turnips
- carrots
- beets
- parsnips

On the brow of obesity man has branded a less lovely epigram than on the brow of diabetes: "This disease I can conquer if I wish, but I do not usually wish, because I am too weak, too uxorious, and too lazy."

GOUT is the disease of protein or protein end-product disorder. It is rarely, though sometimes, seen in America. Some English physicians, on the other hand, have dropped into a fad of calling half the chronic disorders they see gouty. It manifests itself by attacks of pain of the most atrocious severity in the joints, particularly of the toes and fingers. There are deposits of urates in the joints, also in the cartilage of the ear. It is best treated by a drug, atophan, or cinchophen, or its improvement neocinchophen, which reduces pain and stimulates the excretion of uric acid. Elimination of protein food from the diet, and the use of heat- and water-cures are necessary.

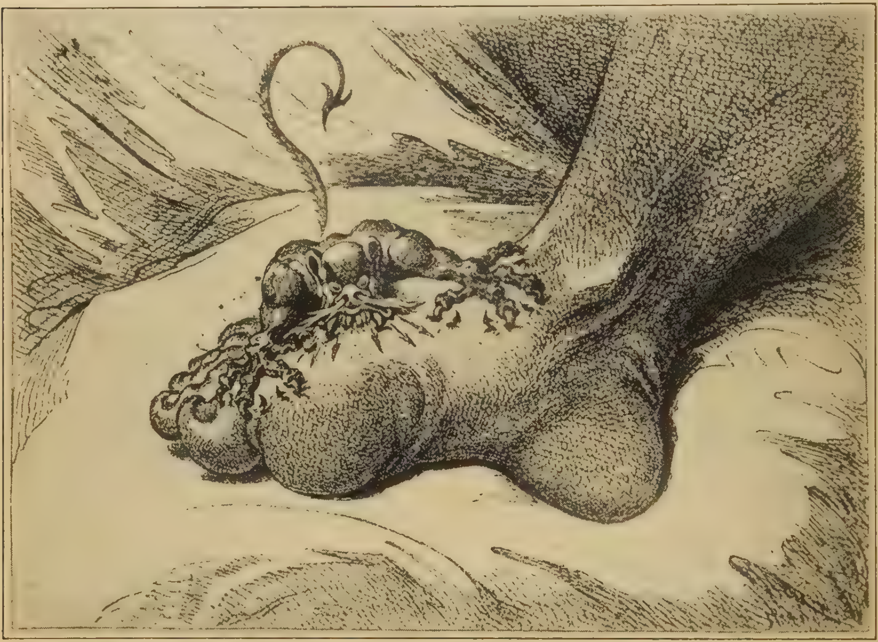


FIGURE 51
Gout (*Cartoon by James Gillray.*)

RICKETS is a nutritional disease of very complex origin, occurring almost exclusively in infants. Because the bones are affected prominently, particularly because calcium is not deposited in the growing bone, it has been called a disease of calcium deficiency. Other factors unquestionably enter into the matter, because the use of cod-liver oil will undoubtedly help to start the bones to laying down calcium, and as cod-liver oil contains no undue amount of calcium, it is possibly because it contains a fat-soluble vitamin which these children need. A curious phenomenon is the effect of sunlight on rickety children. It alone, with no other treatment, will do wonders. It is noteworthy in this connexion that rickets is likely to show up in the spring, after children have been indoors away from sunlight through the winter, and is much more frequently seen in Negro children, whose skin filters sunlight away from the underlying parts and the blood. Supplementing this are some experiments in which white and black rats were given the same prorachitic diet, only the black rats developing rickets. Modern pediatric science has discovered much about the cause and cure of the disease.

SCURVY is produced in all laboratory animals on an inadequate diet. Infantile scurvy, manifesting itself by swellings around joints, often called rheumatism, is usually due to using condensed milk alone as a diet. A fuller diet, particularly giving some orange-juice with its water-soluble vitamin, results in prompt improvement. Adult scurvy, though occasionally seen still, was once a common disease among sailors who went on long voyages with no fresh meat or vegetables, milk or eggs.

OTHER DEFICIENCY DISEASES: Pellagra is a peculiar condition, not infrequently seen in the United States, particularly in masked forms, in which a peculiar change occurs in the skin, especially of the hands and face. It usually can be traced to a faulty diet. Beri-beri, the disease from which our knowledge of the vitamins really sprang, has almost exclusively an oriental distribution and is certainly caused by an entirely rice diet, in which the metacarp of the rice has been removed by a sort of milling process called polishing.

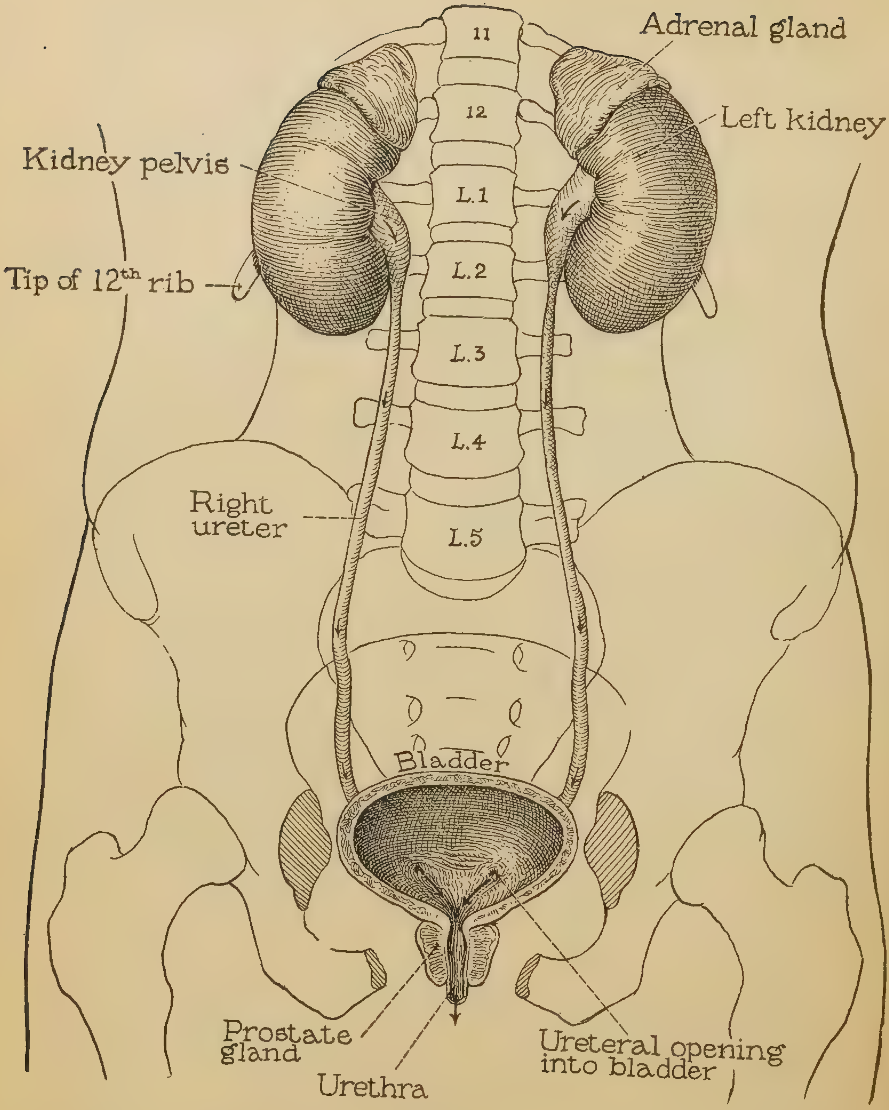

Adrenal gland
Left kidney
Kidney pelvis
Tip of 12th rib
11
12
L.1
L.2
L.3
L.4
L.5
Right ureter
Bladder
Prostate gland
Urethra
Ureteral opening into bladder

FIGURE 52

The urinary system — kidneys, ureters, and bladder. The adrenal bodies are shown on top of the kidneys.

CHAPTER VIII

THE EXCRETORY SYSTEM

Every engine produces some waste products during the period of combustion — ash, smoke, soot. The body is an engine which is no exception to the rule. We have followed the process of the reduction of the combustible food material to a useful state, which process we have called digestion; and the process of absorption of this material into the blood, the absorption of air from the lungs and its entrance into the blood, the distribution of food and air by the circulation of the blood to all parts of the body, and its utilization there by the tissues, which last process we have called nutrition or metabolism. It is really, as we have repeated over and over, a kind of combustion or burning, and certain waste products result. The most constant of these is water. A molecule of water always forms as glucose, the great energizer of the body, is burned. The next most constantly formed waste product is carbon dioxide. Then, of course, the non-digestible residue of food must be got rid of. In the breaking down of tissue and in the utilization of albuminous or protein matter, nitrogenous waste products are formed, the most constant of which are urea, uric acid, creatinine, and creatin.

All of these substances must be thrown off by the body, first because they are useless, second because in some instances they are poisonous, third because they are in the way. Various parts of the body share in the functions of excretion, each doing its part. The bowels excrete in the stool the end products of digestion; the lungs excrete water and carbon dioxide. The skin excretes, in the form of perspiration, water and some salts and a few nitrogenous bodies; perspiration is constant, winter and summer, though, of course, on account of the primary heat regulatory function of the perspiration, more profuse in summer.

The chief excretory route of the end products of albuminous nutrition and tissue waste is by way of the kidneys. The urinary system consists of two kidneys, each of which secretes urine into a closed space, the pelvis of the kidney; of two tubes, the ureters, which conduct the urine from the kidneys to the bladder; of the bladder itself, a hollow muscular organ, guarded by a circular muscle, largely but not entirely under control of the will, and a short canal, the urethra, which conducts the urine from the bladder to the outside.

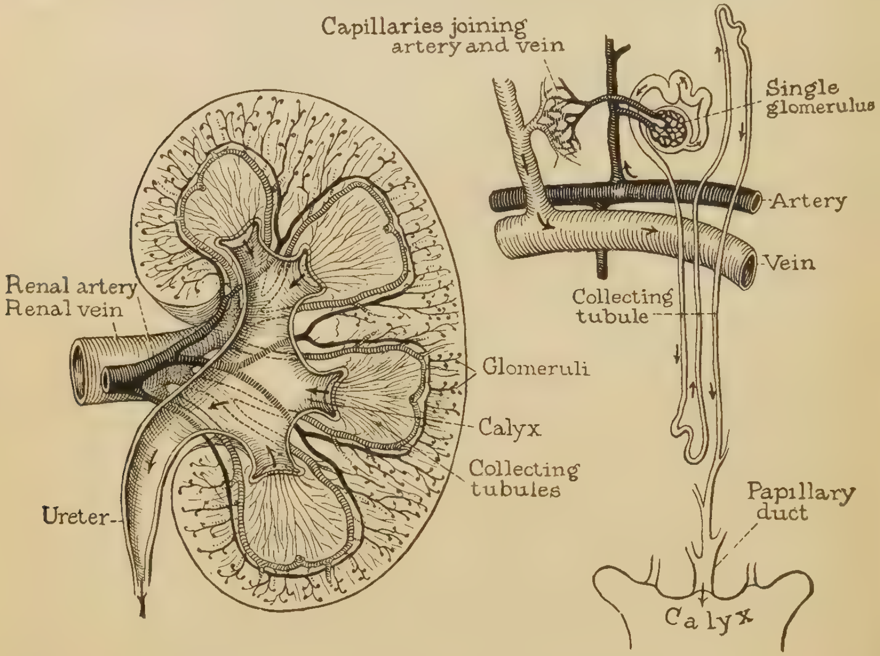

Capillaries joining artery and vein
Single glomerulus
Artery
Vein
Collecting tubule
Renal artery
Renal vein
Glomeruli
Calyx
Collecting tubules
Ureter
Papillary duct
Calyx

FIGURE 53

The finer anatomy of the kidney. To the right, a single tubule. Note that the blood from a branch of the renal artery breaks up into a mesh ball of small blood-vessels which enter a pocket of kidney-cells, the whole being called a glomerulus. Here the kidney-cells extract from the blood the water and salts which go to make up the urine. The urine so formed flows down the uriniferous tubule and collecting tubule, until they join with other tubules of the same kind, emptying finally into a calyx of the kidney pelvis. At one place the transition from artery to vein with capillaries in between is shown. At the left is shown a general view of a cut section of the kidney. Note the glomeruli branching from the renal artery as small tufts. The many collecting tubules are indicated emptying into the calices.

In the male the urinary system has become entangled with the reproductive system. The prostate gland is therefore in the male situated at the neck of the bladder — a ghastly anatomical mistake, for when the male function of reproduction ceases, the prostate in a certain number of cases enlarges and obstructs the exit of the bladder. If the male generative system had been dissociated by a kinder providence from the urinary system and this should happen, no harm would result, but with the prostate enlarging around the neck of the bladder, very serious consequences ensue, and life itself is jeopardized. These conditions are by no means necessary, and depend on one of the stupidest mechanical arrangements possible. I turn the facts over to those who are concerned with the argument from design.

The excretion of urine is made possible by the selective action of the cells of the kidney tubules. The blood is brought to these cells and then spread out through a thin capillary network called the glomerulus; it is a mesh ball of blood-vessels. A glance at the diagram of a series of these tubules (Figure 53) will make the arrangement clear. As the blood courses through the capillary glomeruli, the kidney-cells take up (1) water, (2) salts (such as sodium chloride and ammonia), and (3) waste bodies (particularly the nitrogenous waste bodies such as urea, uric acid, creatinine, and creatin). All of these waste bodies result from the breakdown of albuminous or protein material. The ammonia, urea, uric acid, and creatinine are almost entirely the end products of food waste. The creatin probably comes exclusively from the break-down of the muscles, the living muscles of the body; it is always increased in wasting diseases, fevers, etc. After the kidney-cells remove these substances from the blood, they are washed out of the tubules into the pelvis of the kidney, down the ureter, into the bladder, and then cast off by the act of urination.

The process of urine secretion goes on constantly, at the rate of about a drop every thirty seconds from each kidney. Every physician now has seen this with his own eyes, because the modern genito-urinary surgeon, by sticking a cystoscope into the bladder, can see the opening of the ureters and can place a fine catheter or hollow tube into each and collect urine from each kidney separately. The tubes hang out, dripping into glass tubes so that anyone may see the rate of flow. They also utilize this method to determine the rate of secretion of dyes in each kidney, a matter which will be taken up below. The most frequent and constant use of the cystoscope is to determine whether blood or pus in the urine is coming from both kidneys or only from one, and if from only one kidney, which one; this is important and otherwise unobtainable information, because, of course, if blood or pus comes only from one kidney, the urine in the bladder will become mixed and homogeneous: it will all be blood or pus and there may be no pain or symptom to show from which side the blood or pus comes. It would be impossible to tell this merely by an examination of the urine. But with a catheter stuck in each ureter the urine from each kidney drips into separate bottles and the one which is forming the pus can easily be determined.

The rate of urinary flow may be increased by various agents, which are known in medicine as diuretics. The best known are coffee and tea, which probably act by stimulating the kidney-cells directly. Other agents, such as digitalis, owe their diuretic action to the increased blood-flow they cause through the kidney glomerulus. A favourite diuretic now in general use is synthetic gin.

A number of problems as to the secretion of urine have concerned physiologists. One of these is the place in the uriniferous tubule where the water is secreted and whether the salts and urea are secreted in the same place or in a different part. Another is whether the secretion of urine is due to a selective action on the part of the kidney epithelium or whether the laws of osmotic pressure are sufficient to explain the passage of water and salts from the blood to the lumen of the tubule. None of these various questions have been finally settled, but the research work done to elucidate them has resulted in a constant illumination of many problems in physiology and particularly physiologic chemistry.

It is easy to see that in the kidney itself an interference with the normal excretion of urine may arise either because the kidney-cells become diseased or because the walls of the kidney blood-vessels become thickened. This last condition practically always occurs as the general process of thickening of the arteries advances. It is, in fact, one of the earliest changes noted in the entire arterial system. Hypertension or arteriosclerosis, therefore, always has associated some changes in the kidneys and a certain amount of kidney or renal failure. Many substances can so affect the kidney epithelium as to render it more or less inert or more or less reduced in ability to excrete urine. This "more or less" may range from complete suppression of urine to inability to excrete certain products normally excreted by the kidneys. The substances which affect the kidney-cells in this way are first the toxins or poisons of infectious diseases. Scarlet fever is a good instance in which the attendant physician and nurse are always on the look-out for the onset of kidney disease. Diphtheria is another. Focal infection or those concealed infections in teeth-roots and tonsils and the gall-bladder are others. A second class of destructive substances are salts of the metals, the commonest one found in practice being bichloride of mercury. Death from mercury poisoning is in most cases due to kidney epithelium destruction.

METHODS OF EXAMINATION FOR KIDNEY DISEASE: There are many ways of examining the body to determine the presence and extent of renal failure. Recently, thanks to the labours of many biologic chemists, we have a number of methods of blood examination which determine for us perfectly accurately the amount in the blood of the substances which are normally excreted by the kidneys. It is obvious, for instance, that, inasmuch as the kidney excretes the urea from the blood-stream, if the kidney is diseased and cannot excrete urea, the amount of urea in the blood will be increased over normal. We have exact quantitative methods of measurement to determine the amount of uric acid, urea, and creatinine in the blood, and also exact standards of their normal concentration in the fasting state. This knowledge has helped immensely in evaluating in a given case the functional capacity of the kidneys.

Examination methods dependent upon the ability of the kidney to excrete a certain substance in a given time (renal function tests) are also used. The substance to be used must be easily recognizable, and usually a dye is employed. It must have a constant excretion rate in the urine and this must be determined by trying it on hundreds of normal people. The procedure, with these preliminaries settled, consists in injecting the dye and collecting all the urine excreted from then on for a certain period of time. Perhaps the method will be made clearer by an illustration. At medical conventions after we have been discussing at dinner such weighty matters as why So-and-So of Los Angeles wanted to be put on the board of directors of the Such-and-Such Society and how he went about it, the highballs often compel several of us to repair to the toilet at the same time. It is frequently remarked on such occasions that the asparagus test for the kidneys should be taken up in a serious way. This rests upon the common observation that asparagrine, one of the aromatic ingredients of asparagus, appears in the urine and can be detected by the sense of smell in a very short time after ingestion. (The fact has really divided the population into two groups — one of which naïvely believes that asparagus is good for the kidneys, one of which equally artlessly believes that it is bad for the kidneys.) Kidney tests are founded upon just this principle — the use of a substance which appears promptly in the urine, which is easily recognized, and which can be determined quantitatively, quickly, and accurately.

Of course the oldest method of all of determining the integrity of the kidneys is to examine the urine. It has been done in some way or other since the earliest times. "Sirrah, you giant," cries Falstaff to his tiny page, "what says the doctor to my water?" And the page answers: "He said, sir, the water itself was a good healthy water; but for the party that owned it, he might have more diseases than he knew for." A verdict which is more honest than modern urinalysis institutes deliver.

I find in an old-fashioned commentator — I read *Henry IV* three times a year and I find it more salutary to my health than having my urine examined at regular intervals — an interesting notation on this passage. He says that Linacre, the Oxford humanist, attempted to reform the practice of having apothecaries send specimens of their customers' urine to physicians, because upon receiving the report they conveyed a monstrous verdict to the patient and then compounded a dose of herbs which from all we know of the pharmacology of that day must have been truly staggering in content. Some such reform is needed to-day if I may judge of the way the pronouncements from urine analysis institutes are utilized.

We have many hints as to the methods of urinary examination in the old days. There was, of course, no chemical examination. If you will watch carefully in the galleries of The Hague or Amsterdam or Brussels, you will see many examples of the old Dutch masters' portraits of physicians. Sometimes they are seated by a patient; there is a whole series of *Lovesick Maiden* portraits. A beautiful example is Gerard Dou's *Liebeskrankes Mädchen* at Buckingham Palace; and the *Alte Ärzte* of Teniers at Brussels is another. Invariably the physician is holding a flask of urine to the light and scrutinizing it with an unearthly gravity. No one could possibly be as wise as those old *Ärzte* look. The colour,

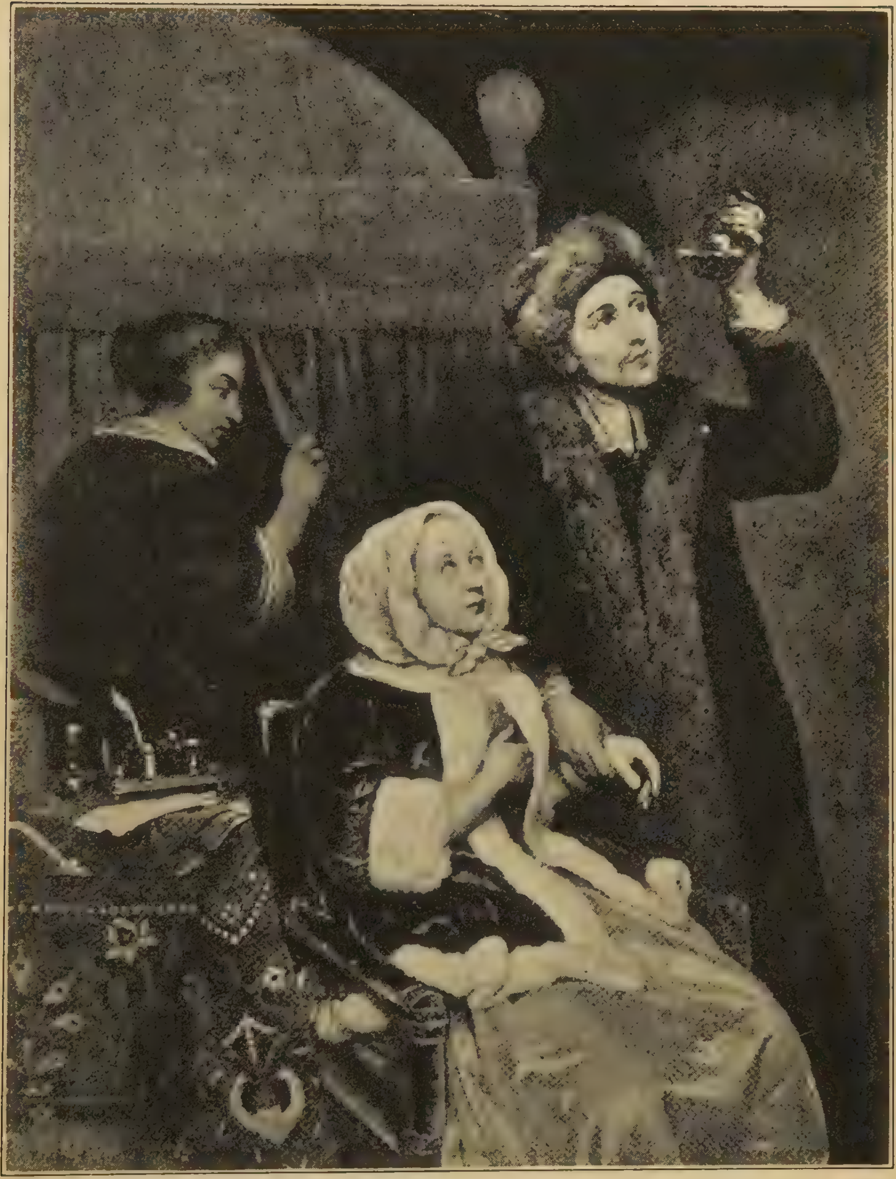


FIGURE 54

"The Lovesick Maiden," by Gerard Dou. Buckingham Palace Galleries. The handsome young physician is examining, for purposes of diagnosis, the maiden's urine, contained in the crystal flask. She appears as much interested in him as in the diagnosis

the glints of light, of course the sediments, were the data upon which they based their diagnosis. Shakspere seems to have been almost as well acquainted with urine examinations as an American captain of industry. "Carry his water to the wise woman," advises Fabian, as Malvolio raves. The wise women drew their conclusions from the way the urine acted when thrown on the fire — if it put the fire out, the prognostic was bad; if a blue flame resulted, it meant impending death; if a green flame, bile. They observed the sediments also, when plated out, much as coffee-grounds now reveal the future and the past. Thomas Willis, an English physician of the Commonwealth and Restoration, seems to have been the first to discover that diabetic urine was sweet, which he discovered by the simple method of tasting.

Anything approaching a scientific examination of urine had to wait until chemistry attained something like maturity. It began with that Richard Bright who remains as an eponym of Bright's disease. He worked at Guy's Hospital in London. It is a hard place for the ordinary visitor in London to find. It is across the river. I used to reach it by walking over London Bridge. Richard Bright, in 1829, discovered that certain patients with dropsy had a coagulable substance like egg-white in the urine when he boiled it in a pewter spoon over a candle. We still employ the method, though we use glass test-tubes instead of pewter spoons. Casts, which are coagulated impressions of the tubules of the kidneys, can be seen under the microscope. The *amount* of urine in twenty-four hours, and the relation of the day to the night urine in amount are important facts. Sediments in the urine, which so frequently frighten patients, are usually of no consequence, being in the great majority of cases salts normally present in the urine, phosphates or urates, which have precipitated on standing. If the sediment is pus or blood, it is, of course, more serious. It is to be remembered that the urine not only represents the deposit of all parts of the urinary tract and thus furnishes some information about the kidneys, the ureters, the bladder, and the urethra, but also is an end product of metabolism and thus can give information as to the whole body.

Albumin does not always mean kidney disease. There are individuals who have albumin in the urine all their lives without any trace of associated renal or bodily disease. It occurs as a very regular accompaniment of certain infectious diseases, such as pneumonia and tonsillitis. In fact, no conclusions of any moment can be drawn from the examination of the urine alone: the physician must see the whole man.

Other diseases besides nephritis or renal deterioration may occur to the kidneys. Tumours are frequent. One such is a peculiar form of cancer called hypernephroma; its outstanding symptom is blood in the urine. Tuberculosis may affect the kidneys and bladder. Pus infections light in the kidney or the kidney pelvis from anywhere in the body.

Stone in the kidney, or in the bladder, is a very common condition. The stones are formed just as stones are formed anywhere in the body. The conditions for stone formation are: a cavity, containing a fluid; the fluid having salts in solution; the entrance of a foreign body. The salts held in solution in the fluid are deposited on the foreign substance. If you allow a string to hang in a solution of sugar, in the course of time you will have a deposit of crystalline sugar on the string; it was the way rock candy was made in the old days. Any object left in a tub of "hard" (or lime-salt-containing) water will have a deposit of lime salts upon it. The foreign objects around which stones form in the kidneys and bladder are bacteria and the small shreds of mucus produced by bacterial infection acting upon the epithelial lining surface. The salts to form stones are always present in the urine, and the stones are either urate or phosphate stones as the case may be. If the stones are very small, they will begin to progress from the kidney to the ureter, causing the most agonizing colic. Childbirth is usually set up as the universal standard of pain; I gather from careful research that an ordinary kidney-stone colic is equal to two childbirths and a miscarriage.

Modern surgery is equipped to care for kidney or bladder stones in the most ingenious ways. "Cutting for the stone," in fact, is one of the oldest of surgical procedures. It was safe for surgeons of the pre-antiseptic era to cut for the stone because in order to gain access to either the kidney or the bladder the peritoneum does not have to be entered. And it was the peritoneum and other serous surfaces which caused the non-antiseptic surgeon his grief, as he well knew. Mr. Pepys was cut for the stone on March 26, 1658, and was very proud of it. But lamentably, on

June 1, 1664, "Mr. Hollyard come to me and to my great sorrow, after his assuring me that I could not possibly have the stone again" (the words have a familiar ring even to those dealing with contemporary surgeons), "he tells me that he do verily fear that I have it again and has brought me something to dissolve it." Mr. Hollyard's fears were justified, nor did the dissolvent do any better than the ones proposed by modern quacks, for when Mr. Pepys died, a nest of seven stones was found in the left kidney. Those who had had the operation in his time used to have their stones mounted in little cases and exhibit them, with, doubtless, elaborate descriptions of their sensations during the operation, which, since no anæsthetics were used, must have "laid over" any of the operation talk-fests of our own day. Under date of August 1 1664, Mr. Pepys says: "I out and among other things to look out a man to make a case for to keep my stone, that I was cut of." And a few days later — "Thence to my case maker for my stone-case and had it to my mind and it cost me 24 *s.* which is a great deale of money."

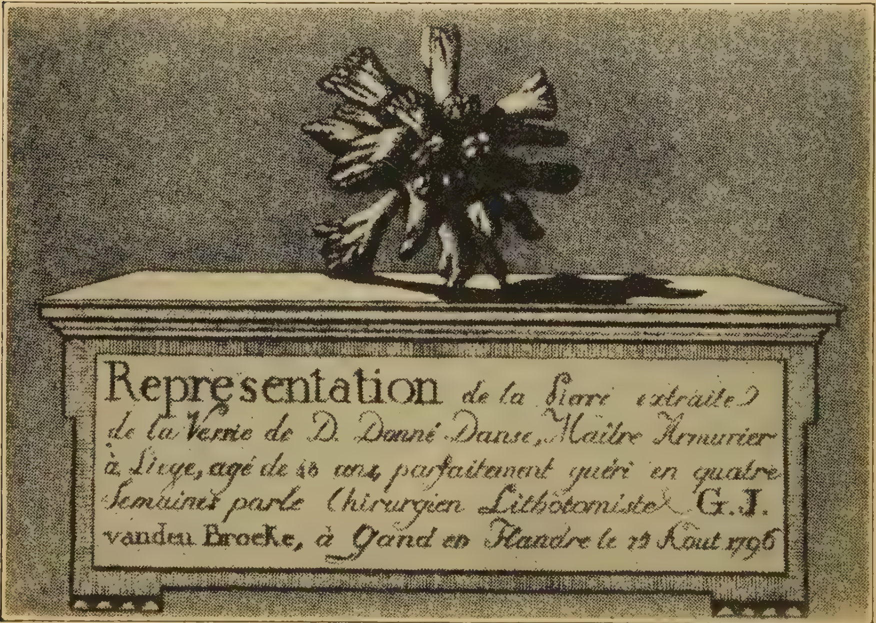

Representation de la Pierre extraite
de la Vessie de D. Donné Danse, Maître Armurier
à Liege, agé de 50 ans, parfaitement guéri en quatre
Semaines par le Chirurgien Lithotomiste G.J.
vanden Broeke, à Gand en Flandre le 19 Aout 1796

FIGURE 55

A stone-case, and the stone removed from the owner. See text for Mr. Pepys's tribulations with his stone-case.

CHAPTER IX

CO-ORDINATION AND CONTROL

THE VEGETATIVE NERVOUS SYSTEM AND THE DUCTLESS GLANDS

In our account up to the present we have spoken as if all these processes of digestion, respiration, circulation, nutrition, and excretion went on automatically, one necessarily following the other on account of the necessities of the case. To a certain extent this is true. What life is, what keeps the process going, we do not know. But there frequently arise times when adjustment has to take place, when one organ fails perhaps momentarily to do its full duty and others must compensate. Especially there arise times when one organ needs more blood, more material, and its vessels must dilate, while the vessels of another organ must contract in order that smooth function be maintained. The co-ordination and control of these things seem to lie in the so-called vegetative nervous system.

It is only recently that the importance of this system has been recognized. Physiologists were content to suppose that the life processes went on when once initiated largely because of the pressure of necessity, largely because they could not help themselves. The story of the vegetative nervous system as finally unravelled constitutes one of the most fascinating of all subjects in physiology.

To obtain a true perspective of the matter we must engage in a short excursion into comparative anatomy. In the scale of animal life nervous tissue begins to make its appearance in a primitive form fairly low in the series. But the majestic central nervous system, with brain, cerebellum, spinal cord, and nerves going out to all parts of the body, does not appear until we reach the vertebrates. In the worm, which is not unlike the primitive fish in general form (without having any bones), we find along the back above the digestive canal a series of nerve-ganglia, connected by filaments to each other; since, however, there is no brain or spinal cord in the worms, they make no connexion with a central nervous system. This series of ganglia is the primitive vegetative nervous system, and persists in the vertebrates and in man. It does all the automatic work of adjustment of the vegetative organs. It is the oldest part of the nervous system, has the most traditions, and is by all odds the most independent — least subject to outside influences. As we see it in man, it consists of a series of ganglia — the sympathetic ganglia — strung along the spinal column *outside* the spinal canal. It sends fibres to all the organs, beginning with the eye and the salivary glands, clear down to the rectum and bladder and womb; also to the blood-vessels scattered everywhere in the body and to the glands of perspiration. Connexions are made to the spinal cord and the automatic parts of the central nervous system so that stimuli originating in the body — skin, gastro-intestinal tract — will provoke appropriate responses.

Early in vertebral development another set of fibres arose from the most primitive and most automatic part of the central nervous system — the medulla and lower part of the spinal cord. These fibres also go to every organ, beginning with the eye and salivary glands, then to the lungs, the heart, the stomach and intestines; to the bladder and rectum and womb. The only parts of the body with which the rest of the central nervous system makes direct connexion are the voluntary muscles, and the sense organs of sight, hearing, touch, etc. — in short, those parts of the body either under control of the will or recording sensations in consciousness.

An involuntary organ then, which does its work undirected by consciousness — such as a salivary or a sweat gland, such as the heart or the intestines — has two sets of fibres — one coming from the sympathetic system, the other coming from the automatic portion of the central nervous system, this latter called the autonomic system. Such fibres constantly carry impulses to the automatically acting organs, and these impulses oppose each other. For instance, in the case of one of the salivary glands, a nerve enters it, the chorda tympani, which belongs to the autonomic system; other nerve-fibres enter it which arise from sympathetic ganglia in the neck. If the chorda tympani is stimulated by an electric battery, a great flow of saliva results; if the sympa-

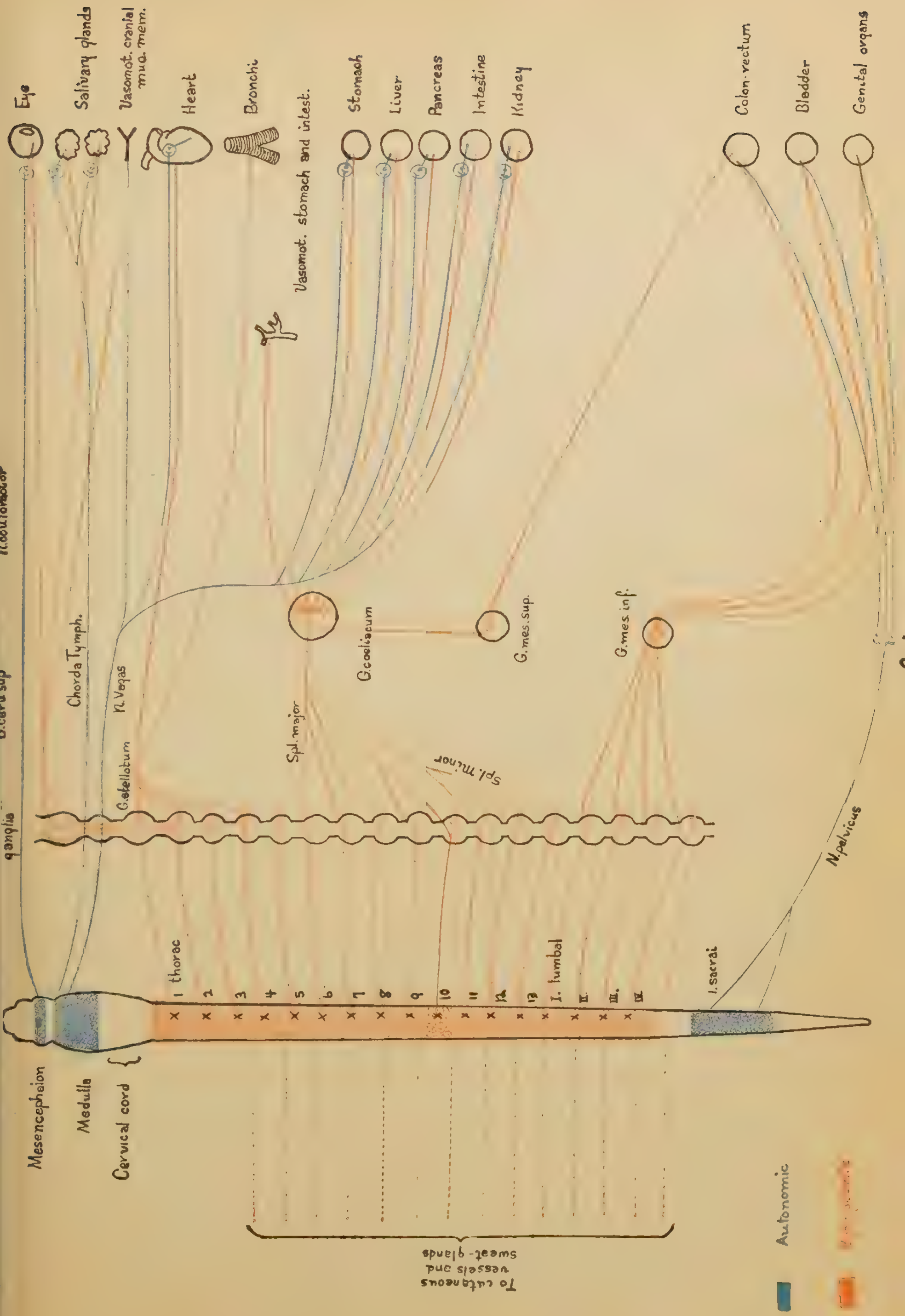

Eye
Salivary glands
Vasomot. cranial muc. mem.
Heart
Bronchi
Vasomot. stomach and intest.
Stomach
Liver
Pancreas
Intestine
Kidney
Colon-rectum
Bladder
Genital organs
N. oculomotor
G. cerv sup
ganglia
Chorda Tymph.
N. Vagus
G. stellatum
Spl. major
G. coeliacum
Spl. minor
G. mes. sup.
G. mes. inf.
N. pelvicus
Mesencephalon
Medulla
Cervical cord
1 thorac
2
3
4
5
6
7
8
9
10
11
12
13
I. lumbal
II.
III.
IV.
I. sacral
To cutaneous vessels and sweat-glands
Autonomic

FIGURE 56. *Diagram of the vegetative nervous system.* (*After Meyer and Gottlieb.*)

thetic nerve is stimulated, the flow of saliva is almost stopped. Thus we have two nerve-fibre systems balancing this function. In the case of the heart, as already detailed, there is a set of nerves which, when stimulated, increase the heart-rate and a set which decrease the heart-rate.

A glance at the accompanying diagram (Figure 56) will make the whole thing clear. It is impossible in this short treatise, and unnecessary, to follow the actions of these two sets of nerves in every organ of the body.

What maintains the normal balance? What changes it? What influences it? It must be said quite frankly that in the present state of our knowledge these things do not admit of a complete categorical answer. We can state that, as the necessities of the body arise, stimuli are sent to one or the other of these systems so that proper adjustment is made. To illustrate that statement, when food is put into the mouth, the sense organs of taste and feeling in the cheek and tongue send stimuli to the medulla so that the chorda tympani is stimulated, and this stimulation overbalances the quieting effect of the sympathetic fibres and produces a flow of saliva. Again, when severe exercise is engaged in and more blood is needed from the heart, the accumulation of carbon dioxide in the blood affects the medullary centre so that the respirations are increased and the sympathetic fibres to the heart stimulated so that the heart beats faster. We assume that these things must be true. We know that the end results described happen.

Furthermore, we know very well that certain drugs have selective actions upon one or the other part of the vegetative nervous system. Prominent among these are atropine, nicotine, and pilocarpine. Atropine paralyses the autonomic nervous system and thus allows the sympathetic system full play. When atropine is used, the pupil dilates, the salivary, sweat, and skin glands dry up, the heart beats fast, and the intestines balloon up. We know that this action is directly on the autonomic system because when the vagus nerve is cut and then atropine given, no change occurs in the rate of the heart-beat; if the chorda tympani is cut and atropine given, the salivary glands do not dry up. The action of nicotine on the vegetative nervous system is seen in the small doses induced by an ordinary smoke, when the blood-pressure rises slightly and the bowels are stimulated to act. Pilocarpine, physostigmine, and muscarine stimulate the autonomic nervous system, thus being antagonists of atropine.

But while the pharmacologic actions of these substances throw great light upon the mechanism of the vegetative nervous system they do not give us any clue to the ordinary regulation of it because, of course, except under unusual circumstances, they are not present in the body.

There is one drug, or substance, or chemical, however, which has a distinct and powerful effect upon the vegetative nervous system and which is always present in the normal body. In fact it is elaborated by two small glands perched on top of the two kidneys on each side. The substance is called most commonly by the name of adrenalin. It is normally secreted by the adrenal bodies, which are ductless glands, so called because they pour their secretion into the blood-stream directly and not into any body cavity by means of a duct. Adrenalin stimulates all of the sympathetic nervous system. Its injection causes a great rise of blood-pressure, a rapid heart-beat, a dilatation of the bronchial muscles, a dilatation of the pupil of the eye, and an increase in the flow of saliva. Its interest for us lies in the fact that probably the entire ductless-gland system — thyroid, pituitary, islets of Langerhans, etc. — has regulatory action by means of secretions called hormones over the vegetative nervous system and through it the vegetative or automatic or unconscious actions of the body. In fact the endocrine system is probably the governor of all these life processes. We do not know in every case such exact pharmacologic action as we can study with adrenalin. But then we must remember that adrenalin acts particularly on muscles and glands the action of which is easy to measure. Other processes having nothing to do with muscle and gland action are necessary parts of the bodily activity. We know certainly that insulin, the product of the islets of Langerhans, has to do with the burning of carbohydrates, and is hence central in the nutritive processes of the body. We know that thyroid extract keeps up the general metabolism rate in the body. Possibly all the endocrine glands act through their influence on the vegetative nervous system.

It behooves us certainly to examine this endocrine system with some particularity.

THE ENDOCRINE GLANDS

If you will examine any animal body, (and that includes any human body), you cannot help seeing certain masses of tissue scattered widely but not seeming to have any reason for being where they are. Though physiologists have only recently learned to know something of what these structures do, their presence has been known from the time of the earliest anatomists; I emphasize this because one would gather from recent popular literature that their existence had until recently been unsuspected. One of them hangs from the base of the brain like a fruit on a thin stalk. It fits into a solid, protective bony cup in the skull. It is called the pituitary body. Another, a large purplish mass of tissue well supplied with blood-vessels, is located at the root of the neck — the thyroid. Two others, the adrenals, sit atop the pole of each kidney like small caps. Still another, the thymus, a large mass of whitish tissue, can be found in the chest of young people, though it atrophies and almost disappears at about the age of fourteen — the age of puberty. These are the most easily seen of the ductless, or endocrine, glands.

There has always been a considerable amount of speculation as to their function. A favourite idea was that one or the other was the seat of the soul. Some little theological difficulty was experienced with this because the lower animals had them too, but, like most theological difficulties, satisfactory explanations — satisfactory at least to the theologians — were dished up and they passed current.

Definite facts about these structures were learned first from their diseases. The thyroid gland, late in the eighteenth century was observed to be swollen — goitre — in some cases with the accompaniment of staring eyes, a general tremor of the muscles, and an exceedingly rapid pulse-rate. Then in certain children — called cretins — the thyroid was found to be entirely lacking; these children were stunted in growth, deformed, and deficient mentally. Later William Gull, whose personality I should like to be able to sketch, if only because he once kicked an editor out of his consultation room, described certain cases of mental deficiency with an overgrowth of fat in adults which seemed to accompany an atrophy of the thyroid gland, and the victims of which condition were restored to normal by eating the thyroid substance of animals — the disease named myxœdema. In 1886 Marie, a French physician, found that in tumours of the pituitary gland an enormous overgrowth of bone occurred, so that actual giants resulted. Addison, a co-worker with Bright at Guy's Hospital, found in destruction of the adrenal bodies a yellowish pigmenta-

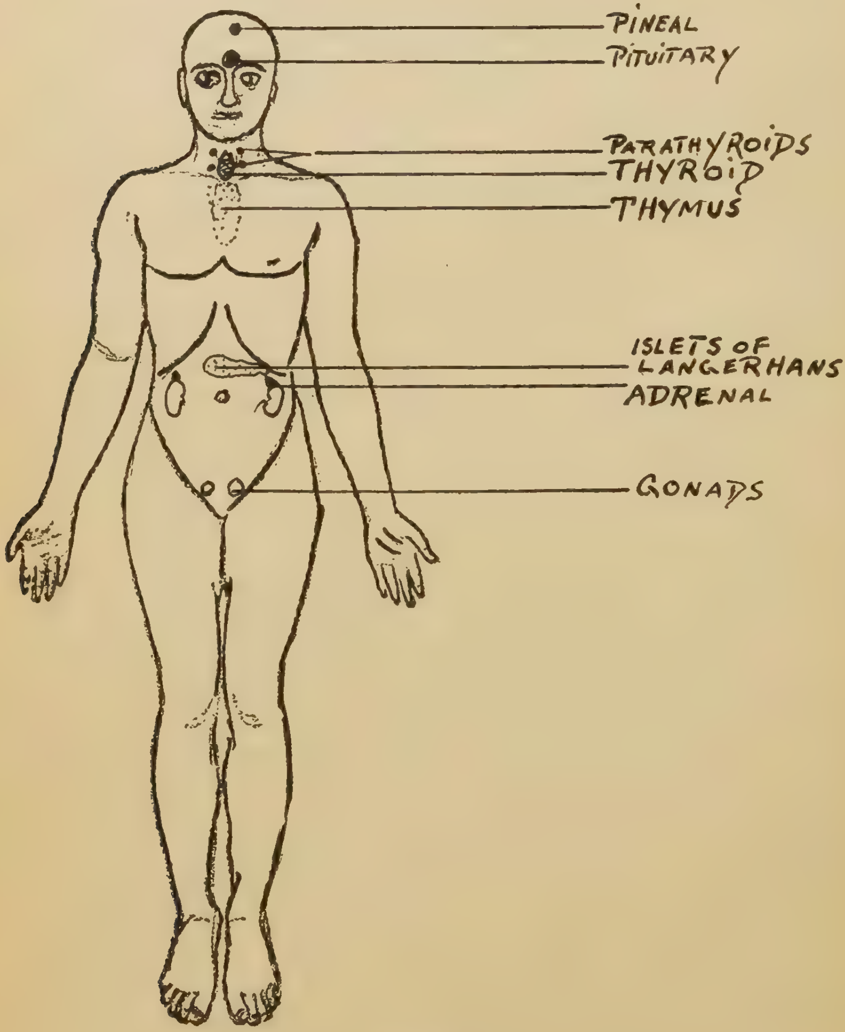

PINEAL
PITUITARY
PARATHYROIDS
THYROID
THYMUS
ISLETS OF LANGERHANS
ADRENAL
GONADS

FIGURE 57
Distribution of the ductless glands.

tion of the skin, great weakness, and emaciation. In this way the study of diseased individuals furnished the hints from which physiologists began to suspect the functions of these bodies.

A number of other glands, not so easily detected as the four mentioned, were later found. The entire system of endocrine glands consists of:

(1) The pineal gland, or epiphysis, situated in the brain posteriorly.

(2) The pituitary, or hypophysis (Figure 35), hanging from the base of the brain and consisting of three parts, differing structurally and functionally:

(a) The anterior lobe, which is plainly glandular, or composed of epithelial tissue.

(b) The intermediate part, also gland-tissue of different structure.

(c) The posterior lobe, consisting of peculiar nervous cells with colloid- or epitheloid-like bodies among them.

(3) The thyroid gland, already described (Figure 32).

(4) The parathyroid glands, four small bodies attached to the back of the thyroid, but differing entirely from it in structure.

(5) The thymus gland, already described (Figure 43).

(6) The adrenal glands (Figure 52), one on each side above each kidney, these consisting of two parts, differing in embryological origin, in structure, and in function:

(a) The outside part, or cortex. This does not occur in conjunction with the medulla in all animals, is derived from the same tissues as the organs of generation — the ovaries and testicles — and really belongs to the reproductive system. Removal of the adrenals always results in death, which is due to the removal of this outside or cortical tissue.

(b) The medulla, or centre. This consists of cellular tissue called chromaffin tissue, which under the microscope is exactly like islets of tissue scattered all over the body, especially in the sympathetic-nerve-ganglia. From this tissue is derived the adrenalin, spoken of in the preceding section, which seems to regulate the activity of the sympathetic nervous system. No adrenalin is found in the cortex of the gland.

(7) The islets of Langerhans — in the pancreas — groups of cells seen only microscopically and concerned with carbohydrate metabolism. When they degenerate diabetes results.

(8) The gonads — ovaries and testicles — which, besides having a primary function of furnishing the elements (ova and spermatozoa) for the formation of a new individual, certainly throw an internal secretion into the body, which, working with other glands — i.e., particularly, the adrenal cortex, the pituitary and the pineal secretions — regulate the secondary sexual characteristics — for instance, the difference in hair distribution in male and female (men normally have beards on the face, women normally do not) and the difference in the pitch of the male and the female voice. We know that the ovaries and testes have some general influence on the body, because, when they are removed, a different type of individual emerges — the eunuch; or when they atrophy in women at the menopause, unusual fat distribution, facial hair, and other changes result.

These eight groups of glands are called the ductless glands, or the glands of internal secretion, because they elaborate secretions which are poured directly into the blood-stream, are poured internally.

Two general principles about them may be laid down:

(1) They form a connected system. They are interdependent. The secretion of one balances or supplements the secretion of another. If one is removed, the entire sequence of events may be upset. For instance, disease of the islets of Langerhans results in lack of sugar combustion and diabetes. But also in states of thyroid activity sugar in the urine may occur. The injection of adrenalin will cause sugar to appear in the urine. Yet in both instances the islets of Langerhans will be intact. What happens? No one can say exactly. We know these things for facts, but cannot explain them completely. Perhaps one secretion *activates* the cells producing another secretion; perhaps the opposite occurs, perhaps it *restrains* their secretory activity. Perhaps in the tissues they mix and supplement, or counterbalance, each other. At any rate it is proper to call all the ductless glands the endocrine system, just as much as to call all the organs of digestion the digestive system.

(2) In general they preside over four functions — (a) growth;

(b) nutrition; (c) sex; (d) the vegetative process of gland secretion and involuntary muscle control. The whole subject of their activities is so interesting, so many experiments have been performed, and so many of these are so bizarre, that the most unrestricted imaginative speculation has been indulged concerning them. Much of this, both that intended for laymen and that intended for physician, is put forward with the solemn appearance of fact. Actually, it is pure arm-chair speculation. I refer to one notable example, a volume entitled *The Glands Regulating Personality*, by Louis Berman. Here we are told with the most solemn appearance of authority that Napoleon was a "pituitary type," and other famous characters are similarly analysed.

Now, of course, all such stuff is pure imaginative speculation. It has the same claim to scientific exactness as Keats's statement that truth is beauty and that is all men need to know upon this earth. It is arguable, I admit, but in order to grace such books with the appearance of verisimilitude, in order to remove their disguise of scientific authority, they should be put in rhymed alexandrines. What I have set down above as the four general functions of the endocrine system represents a summary of all which I believe we can prove in the present state of our knowledge.

For growth, we know in the case of the thymus that just after the sudden growth which occurs during adolescence, the thymus atrophies and this fits in with Noel Paton's experiments which show that removal of the thymus and testes retards growth remarkably. Here we see again the fact that no one gland has a single function, but that they all work interdependently. In congenital thyroid absence we have the stunted growth of cretinism. In the post-adolescent pituitary increase we have the giantism of acromegaly. When investigators first began to study the effects of removal of these glands, or forced feeding of them, on animals, they seemed to be getting into a fairyland where they could produce dwarf forms and giant forms at will. The museums and sideshows have been the best field in the world for the study of endocrine disturbances — the giant, the fat lady, the bearded lady, and the living skeleton (I refer to the ideas of Janney on the endocrine origin of progressive muscular dystrophy and atrophy) all being examples of endocrine disease.

For nutrition, we have the acknowledged part which the se-

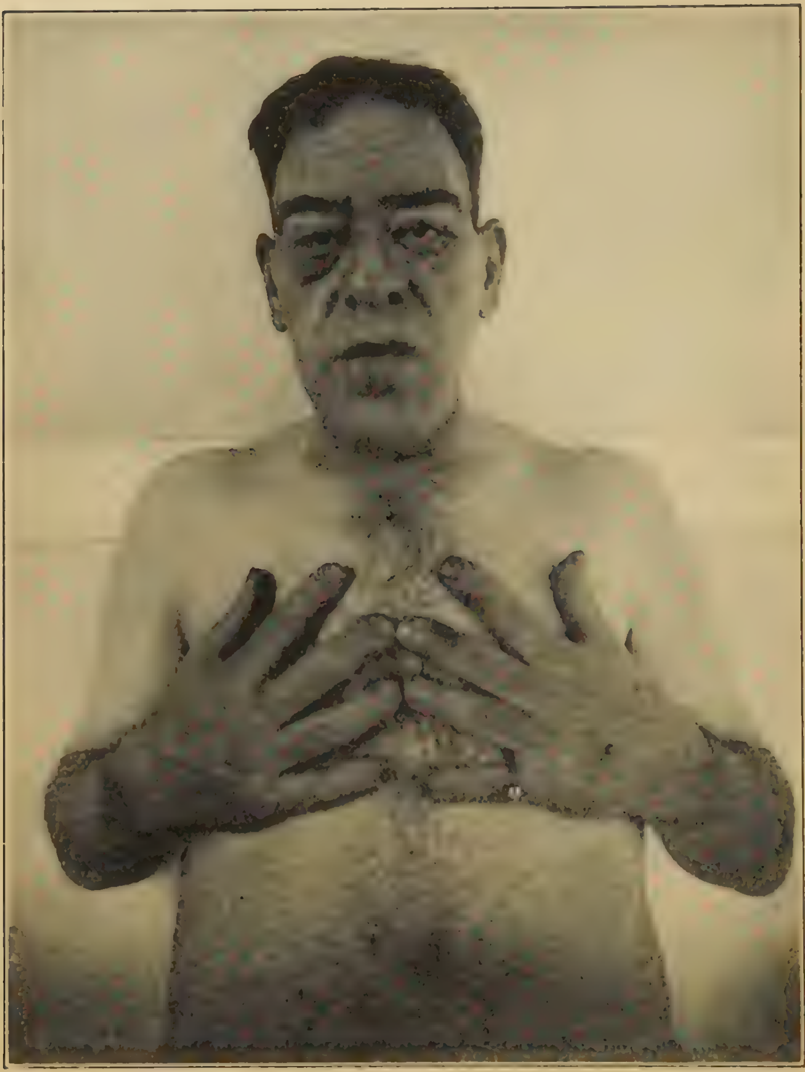


FIGURE 58

Acromegaly, due to increased function of the pituitary gland. Note the enlarged lower jaw and large hands. Compare Figure 3.

cretion of the islets of Langerhans plays in carbohydrate metabolism. Fat nutrition, however, is even more prominently under control of the endocrine glands. The obesity of middle age — after the period of high reproductive activity — shows the influence of the deterioration, particularly of the gonads, on fat distribution. Excessively fat children usually are examples of pituitary insufficiency — sometimes of combined thyroid and pituitary insufficiency. A word should be said here for those heavy children — excessively fat, sexually under-developed, mentally alert though mentally unusual. They constitute a particular disease which may be called Fröhlich's syndrome. These children, because of their peculiarities — the boys are usually effeminate, the girls unattractive — lead lives of veritable tragedy. And it is in many cases preventable if taken early enough — i.e., before the age of two they can be restored to normal with pituitary-gland feeding. The parents of such children seldom realize that they are anything more than a little heavy; they are not considered to be subjects of disease, yet in fact they are. They are usually born fat and heavy, and it may be put down that a baby which when born weighs over nine pounds is likely to have either a thyroid or pituitary deficiency. In either case the feeding of the gland must be begun early, as no good results ensue after three or, at most, five years of age.

Sexual manifestations of endocrine disease may be either impotency or a change in one of the secondary sexual characteristics. We have just mentioned the bearded lady in the circus. The unusual growth of beard upon the feminine face is due to disturbance of the cortex of the adrenal bodies — that part of the adrenal which we have said is derived from the same primitive masses of tissue in the developing embryo as the ovaries or testes. One remarkable case is recorded of a woman who began to develop a beard and a deep masculine voice. About the same time a tumour of the adrenal body was found, and after its removal the hair disappeared from her face, and her voice resumed its normal tone. Practically all the effeminate men and masculine women have either definite disease or at least unbalance of the endocrine secretions.

At this point, of course, the question of mental characteristics in endocrine disturbances becomes debatable. Louis Berman's

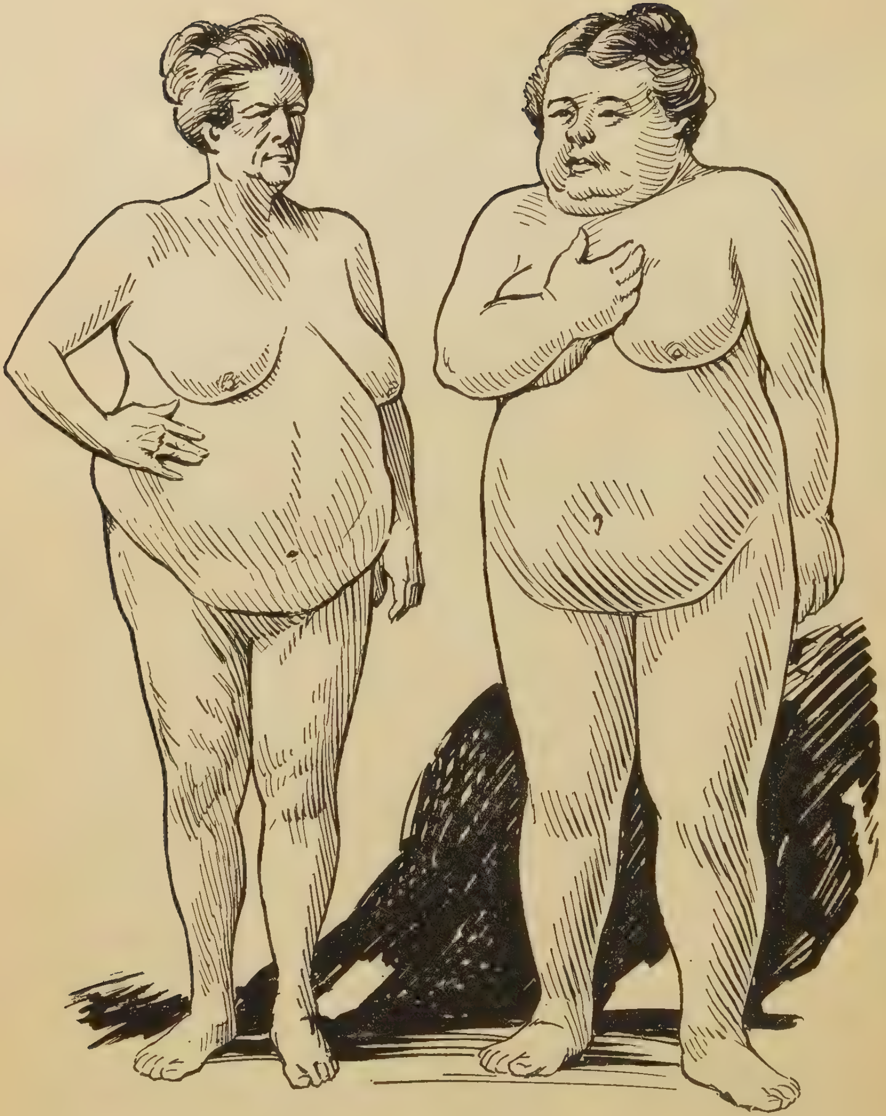


FIGURE 59

Obesity of two types — on the left due to lack of pituitary secretion, on the right due to lack of thyroid secretion. Note that the obesity due to the lack of pituitary secretion is concentrated largely about the waist, while the obesity due to lack of thyroid secretion is generally distributed. The hands and face of the pituitary case are gaunt while those of the thyroid case share the obesity of the rest of the body. (*Redrawn from a photograph loaned by Dr. William Engelbach of St. Louis, Missouri.*)

book, as I have said, is a thoroughly unscientific mass of speculation. But there are men working in the field of endocrinology who believe that certain mental traits do accompany variations in the secretion, or disease, of the ductless glands. One of my friends has an enormous mass of evidence on this subject which he is now tabulating. Personally I am not convinced that there are any clear-cut psychological types — or psychoses — which can be linked with definite endocrine disease, beyond the fact that a person who is a giant, or one who is a dwarf, or a man who is effeminate, or one who is abnormal physically, will have certain peculiar mass mental reactions to the world.

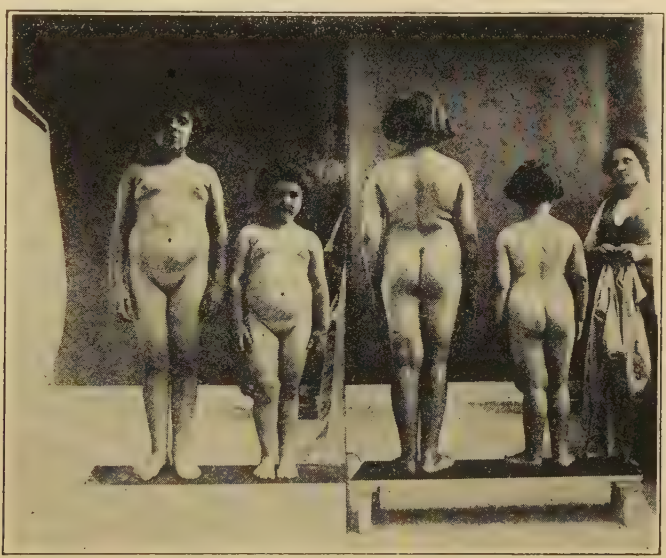


FIGURE 60

Examples of pre-adolescent pituitary insufficiency
Fat children — juvenile obesity.

The diseases of the thyroid gland are better known than those of any other gland of internal secretion. The thyroid normally produces in its substance a secretion, the chemical formula of which is perfectly known, which contains a large amount of iodine. Its function, after it is absorbed into the blood, is to keep up the general level of metabolism. The basic metabolic rate can be measured by estimating the amount of oxygen consumed in a given time: there are instruments which perform this test with accuracy and they are obtainable now by any practising physician. In those diseases of the thyroid in which there is a decrease in the thyroid secretion, as in myxœdema and cretinism, this basic metabolic rate is low; in those conditions in which there is an excess of secretion, as in exophthalmic goitre, the basic metabolic rate, or the actual consumption of oxygen, is high. It is felt to be justifiable, therefore, to say that the thyroid is the general regulator of the bodily metabolism.

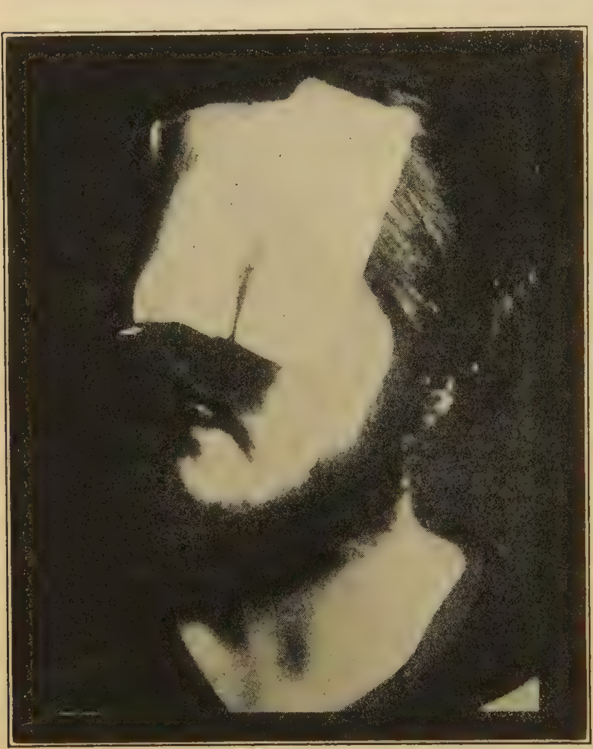


FIGURE 61

A bearded lady, adrenal cortex disease. (*Case of Dr. William Englebach of St. Louis, Missouri.*)

Its secretion, as has been said, contains a large amount of iodine. In certain regions of the world a good proportion of the population has enlargement of the thyroid gland. These regions are known as goitre regions and the condition as endemic goitre. The best known of these is Switzerland and the Swiss Alps. In the United States there is such a region surrounding the Great Lakes. A chemist, McClendon, has examined the water and soil from such regions and also from other parts of the United States. He found that in the goitre region of the Great Lakes the water and soil contained a much smaller amount of iodine than do the water and soil of other regions. The exact proportions can be seen by examining the map (Figure 62). Notice how exactly the incidence of goitre rises as the amount of iodine in the water decreases. This means that in such regions the individual does

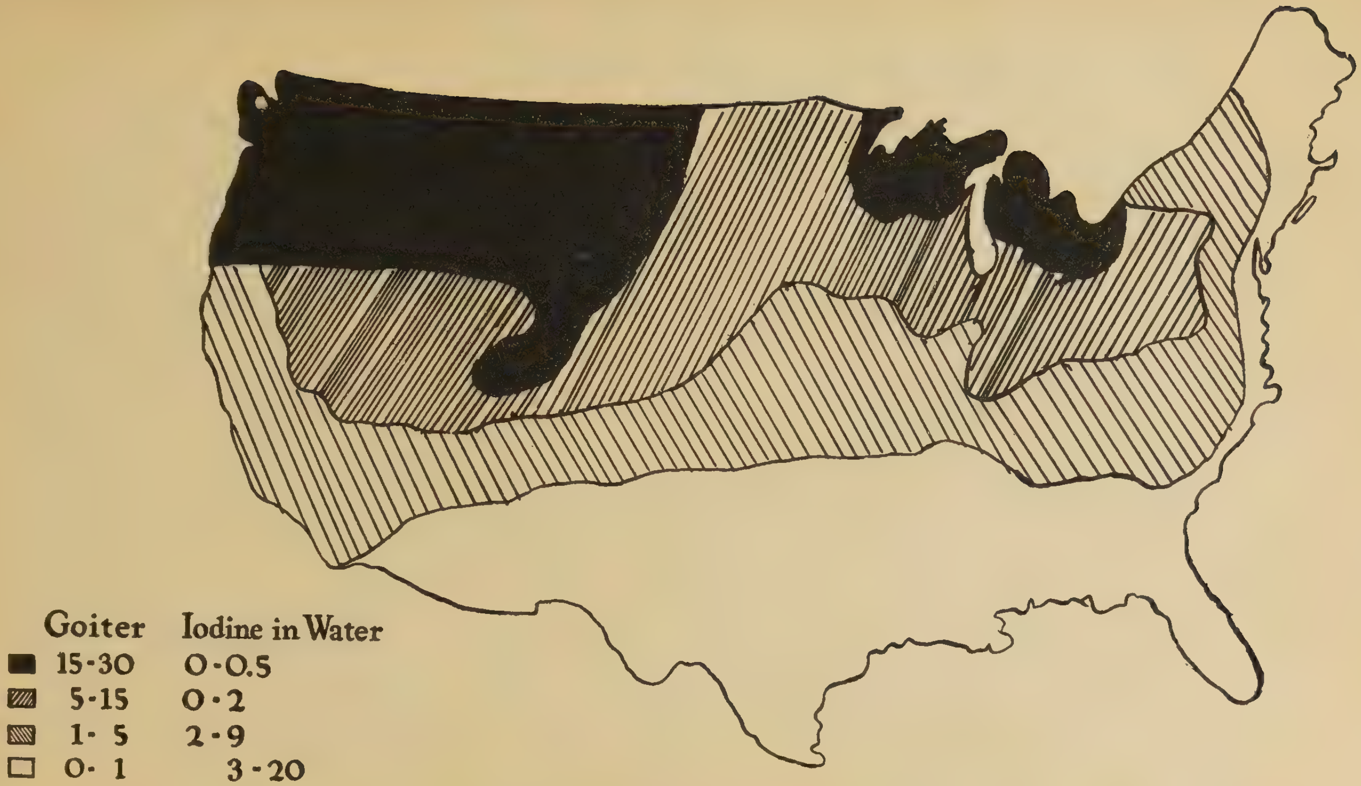


FIGURE 62

The goitre regions of the United States. The figures show the goitre rate per thousand in drafted men (Table XXXIII. Defects found in Drafted Men, War Department, 1920) and iodine in parts per billion of water of representative rivers. (From McClendon and Williams, Journal of the American Medical Association, March 3, 1923.) Note that as the amount of iodine in the water increases, the amount of goitre incident in the population decreases.

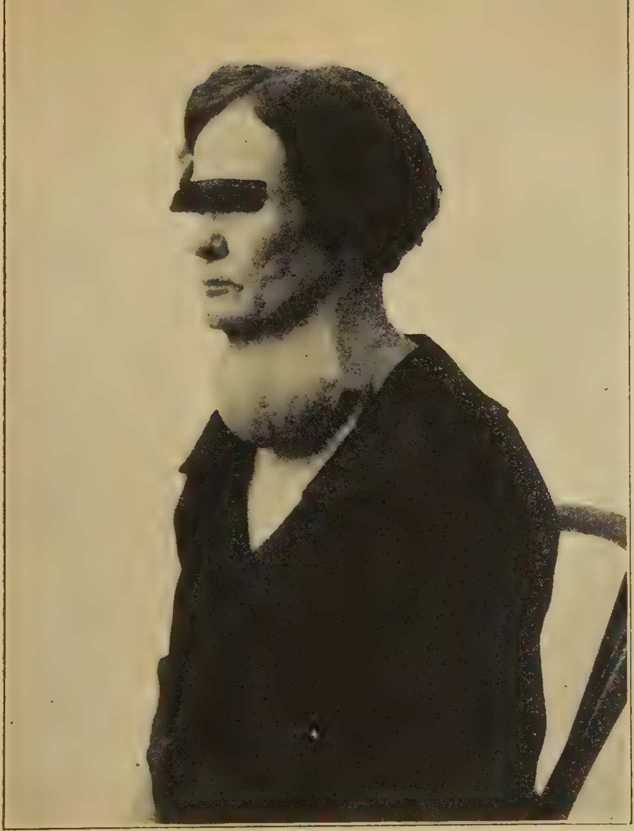


FIGURE 63

A goitre. This form of goitre — colloid goitre — does not cause as serious symptoms as the exophthalmic form. The danger is from its size. These colloid goitres may, however, become toxic. This patient was cured by a surgical removal of the goitre, and is

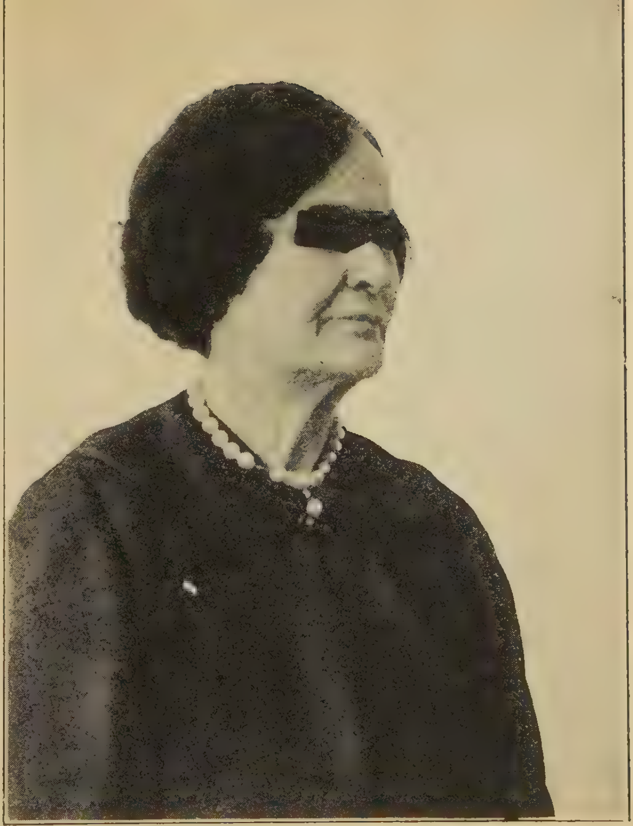


FIGURE 64

Same patient as Figure 63, after surgical removal of the goitre.

not have in his ordinary food and water an adequate amount of iodine, and iodine is absolutely necessary for the functioning of the thyroid. The fact that there is a low iodine content in the soil means that the vegetables grown in such soil and eaten by the inhabitants of that region contain a low content of iodine compared to vegetables grown elsewhere. The goitres, or enlargements of the thyroid gland, in such regions are therefore merely compensatory enlargements. Every gland unit of the thyroid enlarges in order that every bit of iodine which does circulate in the blood can be taken up and utilized. The prevention of such goitres has been found to be very easy. Kendall and Marine, two Cleveland investigators, have found that by giving iodine to schoolchildren over a short period of time twice a year, in the spring and fall, in goitre regions, the occurrence of goitre is almost entirely prevented. They compared large schools in one of which all the children were given iodine and in another of which no iodine was administered, and the incidence of goitre in the first was found to be 16% less than in the other. This preven-

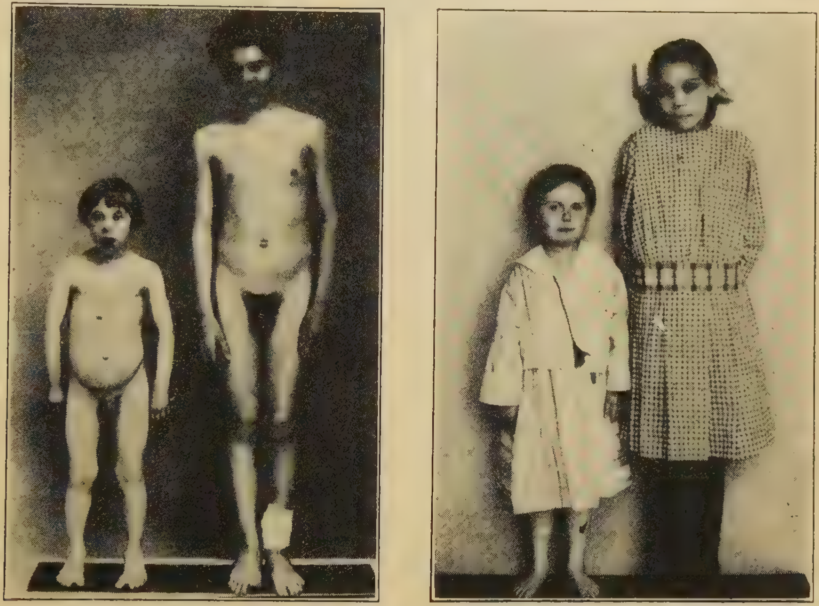


FIGURE 65

Examples of cretins (at left) beside normal children of the same age. Cretinism is lack of thyroid secretion in a child.

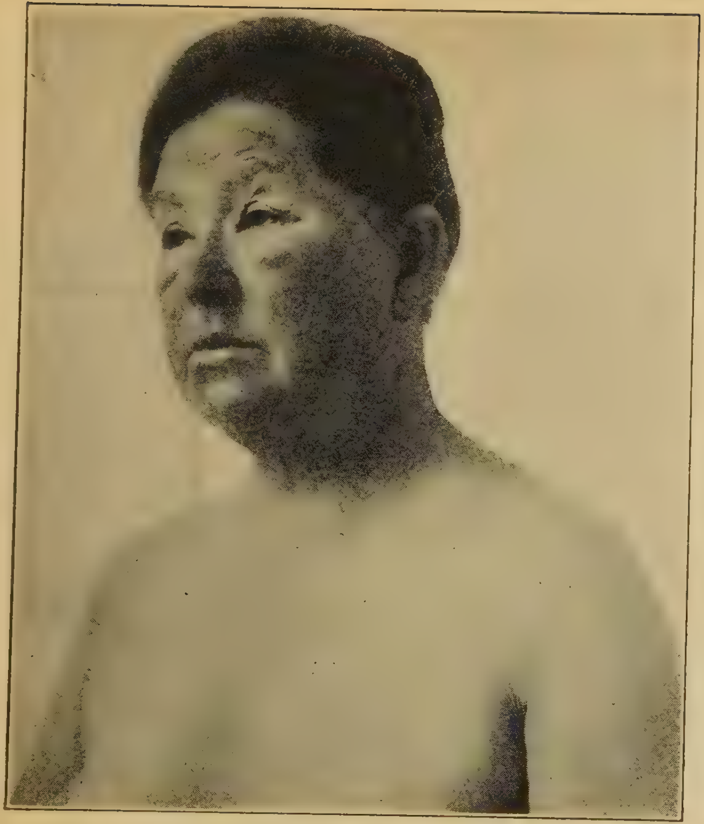


FIGURE 66

A case of myxœdema or lack of thyroid secretion in an adult. Before taking treatment.

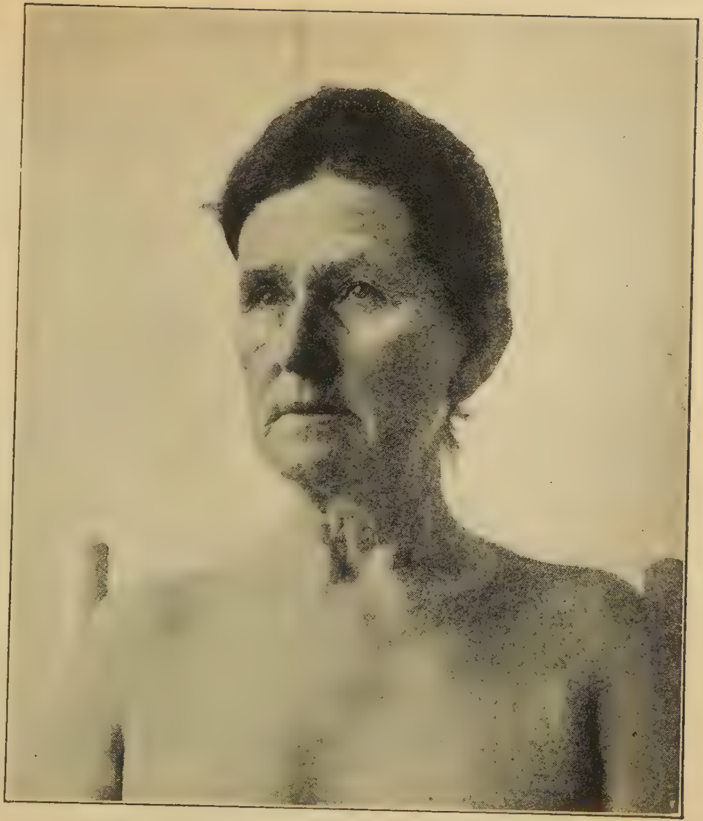


FIGURE 67

Same case as Figure 66, after taking thyroid extract. (Case of Dr. William Englebach of St. Louis, Missouri) tion of goitre is one of the most valuable and striking pieces of research done in our day.

The thyroid also enlarges in girls at the time of the onset of the menses. It also enlarges in women during pregnancy. This illustrates the relation between the thyroid and the sexual, or reproductive, functions. There was a curious item in the old Roman law — a test of virginity by the measurement of the size of the neck. One important lesson of all this is that enlargement of the thyroid does not necessarily mean disease — it is simply a compensatory enlargement.

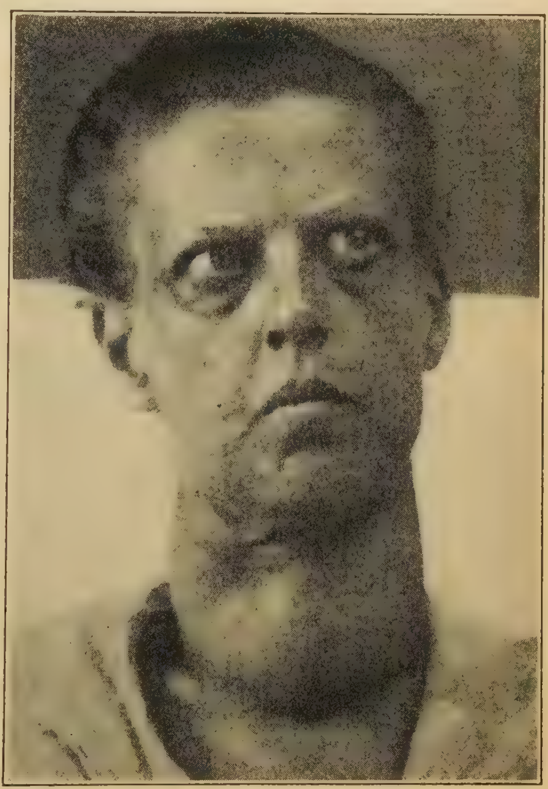


FIGURE 68

An exophthalmic goitre. In this form of goitre various symptoms — protrusion of the eyeballs, rapid pulse, trembling, and loss of weight — accompany the thyroid enlargement. Note in this photograph the enlargement of the thyroid at the base of the neck, and the protrusion of the eyeballs. The expression on the face of the patients has been called "frozen terror."

Exophthalmic goitre, in which the thyroid enlarges (though this is not an absolutely necessary accompaniment, as in some patients we see the other symptoms without thyroid enlargement and assume that the *secretion* is increased though there is no anatomical growth of the gland) and the eyes protrude, the muscles tremble and the pulse-rate is increased, is a bizarre disease the cause of which is not certainly known. It seems to be initiated by a strong emotional shock. Soldiers come out of battle with the disease fully developed. The general aspect of the patient is that of extreme terror — staring eyes, trembling, fast heart — and fright unquestionably brings it on in some cases. After it is established, it runs a course of years and it is agreed that the symptoms are caused by an abnormal secretion — not simply an increased secretion, as some think — of the gland. The accepted method of treating it is by surgical removal of the thyroid, although cases get well under medical management, as witness the life history of Christina Rossetti, who was afflicted at the age of about thirty and lived to be sixty-five.

The parathyroid glands have only recently been successfully studied. Their secretion has been proved to have a direct influence on calcium nutrition. The exact amount of concentration of calcium in the blood influences the contraction of the muscles. When the calcium is low a state called tetany develops in which trembling and incessant activity of the muscles occur. Simply administering calcium will not relieve it. But if calcium and the extract of the parathyroids both are introduced into the body, the condition passes off immediately. The extract has been isolated in pure chemical form by Dr. J. B. Collip of Montreal.

The excessive activity of the parathyroids has even more interesting possibilities. A somewhat rare disease, multiple myeloma, in which malignant tumour masses develop in many of the bones, can frequently be arrested in its course by the removal of the parathyroids, or even one of them which has enlarged. The new growths in the bones melt away and healthy bone replaces the sites of their previous activity. The thought is almost inevitable that possibly all tumours and even cancer may be controlled along the same lines.

(Reference. Barr, David P. "The Syndrome of Hyperparathyroidism." *American Journal of the Medical Sciences*. 1930.)

CHAPTER X

THE CENTRAL NERVOUS SYSTEM AND THE SIX SENSES

It is a hardy spirit which undertakes to give an account of the central nervous system within the limits of a chapter in a book of this size. I glance at some of the accumulated literature on the nervous system on my shelves and am appalled. Over there is a set of twelve tall, thick books in German dealing only with the relation of the eye to the central nervous system; it does not even consider the eye as an optical instrument. Beyond is a late work, Tilney and Riley's *Anatomy and Physiology of the Central Nervous System*, which runs to nine hundred and forty-four huge pages. There is a volume, larger than this book, which gives simply an account of the cerebellum. When we turn from the normal to diseases of the nervous system, the volumes increase in bulk to Gargantuan dimensions.

But no broadly philosophic view of the human organism can fail to assign the central nervous system the place which is that of the holy of holies. Without it we should be senseless, sightless, soundless, motionless masses of multiplying protoplasm. Everything else about the body is vegetative. Which means like a plant. A plant can neither move, nor feel: its life processes are carried on in response to the most primitive chemical and physical changes in its immediate environment. The central nervous system gives us every contact which we ever possess with the rest of the world; it responds to those contacts in terms of agreement or of repulse. In some mysterious manner it furnishes us with every association, every pain, and every delight which we experience throughout our lives. The pain and the delight are linked: they are embodied in the same masses of protoplasm; we could not have one without the other.

So, while it is not possible to describe it in any detail, we must try in some way to give a brief description of the general manner in which it operates. What I hope to do is to suggest an answer to the question which is fundamental — what is the nature of nervous activity? We shall see, I believe, that it is a mass of reflexes. A reflex is a response to a sensation. Therefore we must first inquire what is a sensation? In order to do so we must take a brief excursion into the field of the anatomy of the central nervous system.

The anatomy of the central nervous system will be understood in its simplest form, I think, by examining a unit of the central nervous system, which is a nerve-cell, or a neuron.

Turn to the diagram of a typical neuron (Figure 70). It consists, you see, of a large cell-body, with nucleus and cytoplasm. From that cell-body a long fibre extends out. This fibre makes connexion with some part of the periphery or outer part of the human body — in the cell represented it makes connexion with a muscle. The fibre is a part of the nerve-cell: it connects the cell-body with the muscle. Impulses from the cell-body travel along the fibre and are transmitted to the muscle; they result in muscular contraction; nervous energy is transformed into muscular energy. Another cell might be represented with a fibre going out to a different sort of structure — to the skin, for example (Figure 71). In this case the impulse would go, not from the cell outward to the peripheral structure, but from the skin inward to the cell, carrying the sensation of feeling. It will be noticed also, in the diagram of a typical neuron, that besides the fibre which goes out to the peripheral structure — muscle or skin — there is another fibre coming off from the opposite side of the cell and apparently lying in space — i.e., connected with nothing in particular. That fibre is prepared to make connexions with similar fibres from any other nerve-cell, receive an impulse or stimulation from it, and transmit that stimulation along its fibre to the muscle. Still a third type of neuron could be represented. This neuron would have no fibre attached to any peripheral structure. It would have two fibres attached to nothing in particular. It would be prepared to transmit a nervous impulse from one nerve-cell to another. This simple sketch contains the germ of all the functions of the nervous system. Essentially the nervous system consists in myriads of cells of this kind, grouped together in masses called ganglia, each connected by fibres with other nerve-cells or with peripheral structures.

If the bony cavity which encloses the central nervous system were laid open from skull to tip of spine, we could see that it is composed essentially of masses of nerve-cells called ganglia and of their connexions. These ganglia are superimposed on each other, the more complex above, the less complex below (Figure 69). Thus at the bottom is the spinal cord, consisting of relatively simple masses of nerve-cells with fibres running upward and downward outside of these nerve-cells, the fibres carrying impulses to or from different masses of nerve-cells. Above the spinal cord are the medulla oblongata and the cerebellum — more complex and larger masses of nerve-cells, still with cords of fibres running between them to higher and lower centres. Above the cerebellum is the brain, consisting of very large masses of nerve-cells, the entire rind of it being a huge collection of nerve-ganglia. These are connected together by nerve-fibres. Note in this description that we speak of masses of nerve-cells and collections of fibres. Since they actually are of that colour, these are distinguished in the ordinary talk and writings of neurologists as grey matter and white matter, the cell-masses being grey matter, the fibres white matter.

In looking at this central nervous system with its bony covering removed another point will catch your attention. Entering it from all parts of the body are nerve-fibres. Or rather, if we wish to see it with the penetrating eye acquired after a study of the minute anatomy of these fibres, some of them are entering from outside, and some are emerging from it and going out to various parts of the body. If we follow one of the fibres which is entering the central nervous system back to its point of origin, we may discover that it begins in the skin in a flattened-out termination of the nerve-fibre, which we will call, as everyone else calls it, an end-plate. It is a sensory end-plate in the skin, designed for feeling, and the nerve which goes from it to the central nervous system is a sensory nerve, carrying impulses, in this case impulses of feeling, from the skin to the great central ganglia. Some of these end-plates, designed for special forms of sensation, may be very elaborate, such as the sensory end-plates of the optic nerve in the eye, designed for receiving vibrations of light and translating them into impressions of sight.

If now, continuing our investigations, we follow one of the

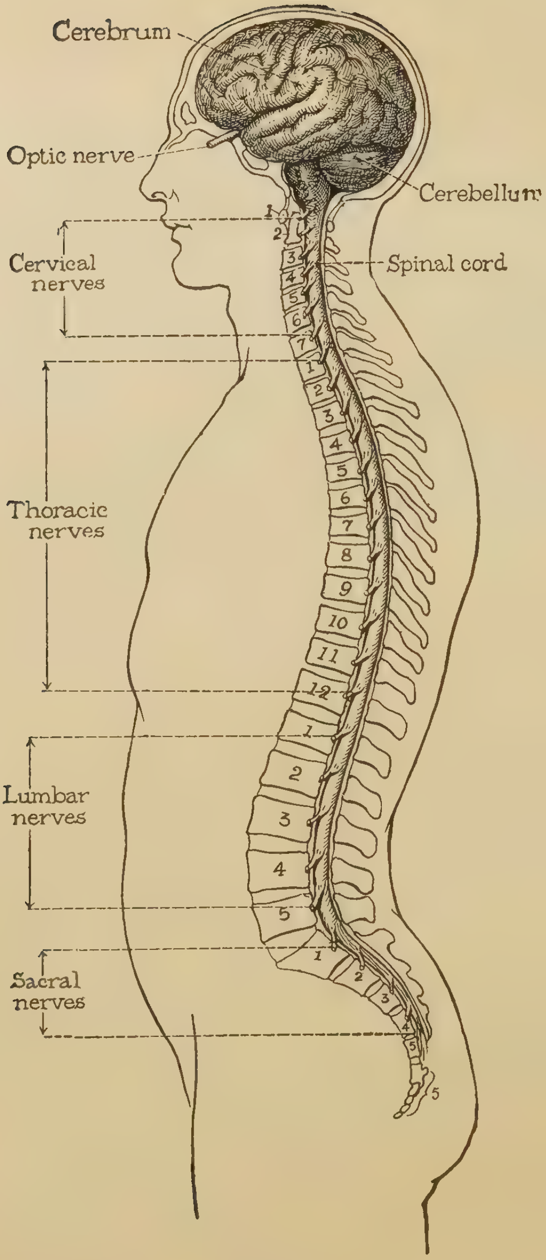

Cerebrum
Optic nerve
Cerebellum
Spinal cord
Cervical nerves
Thoracic nerves
Lumbar nerves
Sacral nerves
1
2
3
4
5
6
7
1
2
3
4
5
6
7
8
9
10
11
12
1
2
3
4
5
1
2
3
4
5
5

FIGURE 69

General view of the central nervous system.

nerve-fibres which originate in the central nervous system and go outward, we find that it terminates in an end-plate also. This end-plate is always of simpler character than any sensory end-plate and terminates in a muscle. These are motor end-plates and the nerves of this character are called motor nerves.

We find, then, that we have two sets of nerves, one set, the sensory nerves, carrying impulses from the end organs of sense in the skin and joint surfaces or from special sense organs such as the eye or ear to the central ganglia, and another set, the motor nerves, carrying impulses from the central ganglia to the muscles. The impulses which go from the outside in are called afferent impulses, and the impulses which go from the inside out are called efferent impulses.

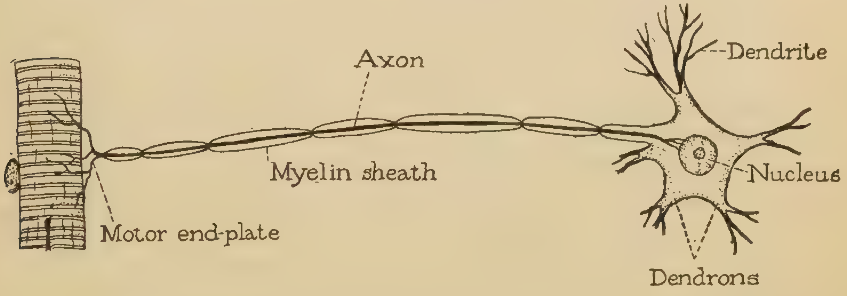


FIGURE 70

A motor-nerve-cell, or neuron, showing its connexion with a voluntary-muscle-cell. Note the aborization of those tentacles of the nerve-cell (dendrons) which are not attached to the muscle-cell. The nerve-cell is through this network ready to receive an impulse from many sources.

Is there any other kind of impulse which flows along these fibres besides sensory or motor impulses? Yes, there must be. When a certain nerve is stimulated and a gland begins to secrete, an impulse travels along that nerve-fibre, and it is not sensory, and, though it is efferent, it is not motor. Most such impulses, however, relay through the vegetative nervous system. Fibres from all the sympathetic ganglia along the anterior surface of the spine enter the spinal cord, usually by way of the sensory spinal ganglia. So that the old primitive vegetative nervous system, which does the work of all the somatic functions of the body, is connected with the historically newer central, and if I may use the word in a rhetorical, not a scientific sense, in order to make a distinction, the *conscious* nervous system.

We must carry our brief anatomical survey of the central nervous system a step further. Let us follow every connexion of a single sensory fibre after it leaves the end-plate in the skin (Figure 71). The fibre runs along in a nerve-bundle until it reaches its cell, which is in a spinal root ganglion lying just outside the spinal cord. Every nerve-cell has at least two fibres, axons and dendrites as they are called, emerging from it, so that from one it can receive, by the other transmit, nervous activity. These two fibres in the sensory spinal root ganglion form a T-shape, one end of which we have just followed to the cell, the other of which leaves the cell and enters the spinal cord by the posterior nerve-root. Here it breaks up into a set of filaments which are in contact with at least a half-dozen other filaments coming from other nerve-cells. It is important for us to understand what are the connexions of the single sensory nerve-cell. One is immediate to a cell in the anterior or motor part of the grey matter of the cord. From this anterior-horn cell a fibre goes out in a nerve to a muscle near that part of the skin in which the sensory end-plate from which we started is located. Here, then, is an immediate possible nervous response. If that sensory end-plate in the skin were irritated (burned, pinched), the impulse would travel along the sensory nerve, race through the spinal-cord level, be transferred to a motor nerve, and a muscle would pluck the irritated spot away from its irritation. The first association, then, is from a spot of sensation in the skin to a spot of muscular response near by. But the sensory cell has many other connexions. It sends long fibres up the spinal cord, which enter the cord at other levels and make sensory and motor connexions. The result of this is that if the irritation to the sensory end-plate be strong enough, large areas of the spinal cord will be involved and pain and movement be widespread instead of, as in the first case, simply local. Then a fibre goes upward clear to the medulla oblongata, ending in the nucleus cuneatus, or the nucleus gracilis. From these again a series of connexions are made, one fibre going to the cerebellum. Remember these various connexions of the cerebellum when we come to consider its especial functions. Still other sensory fibres ascend past the cerebellum and go to the brain, some to the lower brain ganglia (the optic thalami, and the corpora quadrigema) and some to the cortex of the brain itself,

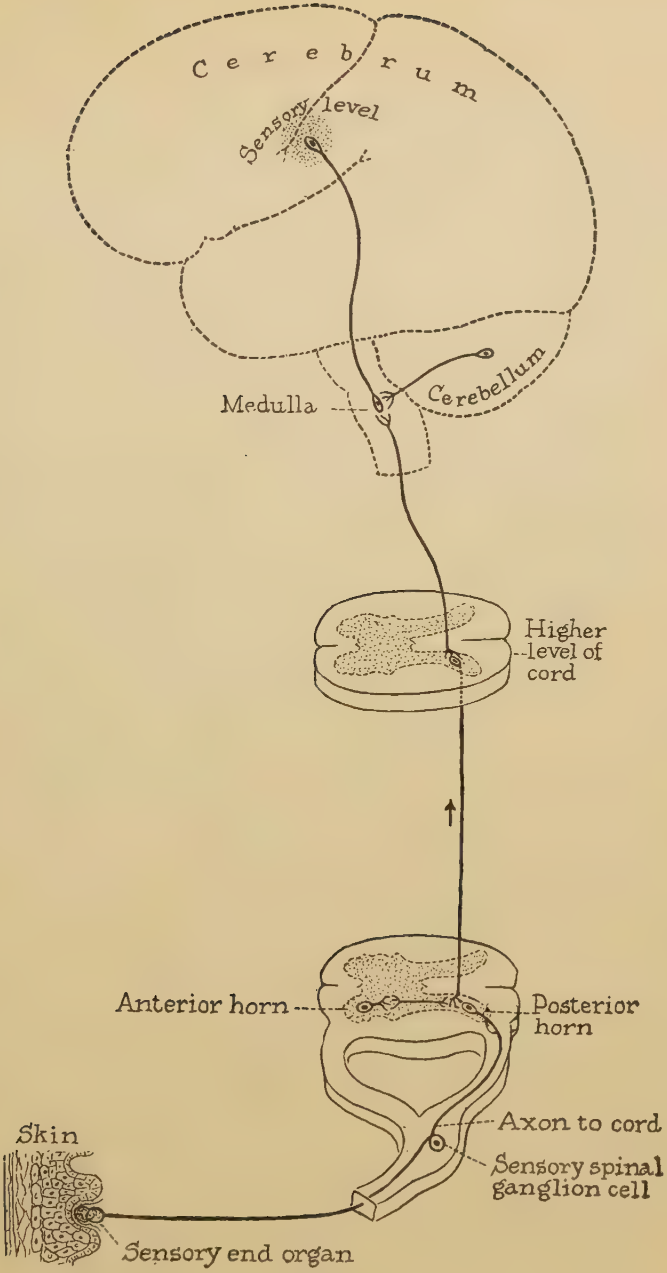

Cerebrum
Sensory level
Medulla
Cerebellum
Higher level of cord
Anterior horn
Posterior horn
Skin
Axon to cord
Sensory spinal ganglion cell
Sensory end organ

FIGURE 71

The course of a sensory fibre from the skin to the brain. The sensory columns decussate (pass over to the opposite side) in the same manner as the motor fibres, but the representation would have been too complicated to show in this diagram.

where, if impulses reach to that point, they are established in consciousness.

We could follow a motor fibre in the same way as we have followed this sensory fibre (Figure 72). The motor fibre *arises* (the sensory fibre *terminates*) in a cell in the brain cortex, crosses over to the opposite side of the spinal cord, establishes connexions with ganglia in the cerebellum and medulla on the way down, goes through the pyramids, and *terminates* in connexions with cells in the anterior root of the grey matter in the spinal cord. From here it sends out fibres to muscles (or in a few cases to glands).

An outstanding feature of the association of the fibres from the cortex to lower levels is that both the sensory and motor fibres cross over after they relay at the medulla and go to the brain cortex on the opposite side from that of the muscle or skin area in which they originated, so that if the motor area of the cortex of one side of the brain is destroyed, the muscles on the opposite side of the body will be paralysed.

We are now in a position to answer the questions concerning nervous activity which we proposed to ourselves. It is unnecessary for you to have followed in detail the various lines of association I have pointed out, but you can from a superficial reading of them see that the central nervous system is essentially a number of masses of nerve-cells connected to each other by a complex set of fibres. The function of a nerve-cell is to interpret the impulse brought by the nerve-fibre, and to initiate new impulses to be sent out over other nerve-fibres. It is like a telephone-exchange system in which the individual telephone is the nerve-cell and the wire the nerve-fibre; the telephone exchanges are the large ganglia where the impulses or messages are relayed to their appropriate destinations. We may even venture to define nervous activity for the moment as a mass of reflexes or as the translation of one form of nervous impulse into another.

Here a curious fact comes to notice. If we take a purely sensory nerve, such as the fifth cranial, which goes to the face, cut out a portion of it between its origin and termination, and replace this cut-out strand with a fresh strand of fibres from a purely motor nerve, the nerve-fibre will heal up in the course of time. (A nerve-fibre will regenerate, provided the nerve-cell to which it belongs is intact. A nerve-cell once destroyed is destroyed for ever.) It will take some weeks, for nerve tissue regenerates more slowly than any other, but when it gets through, we shall have a sensory nerve with a splice of what was originally motor-nerve tissue in it. Yet the impulses which go along that nerve will always be sensory. The point I am endeavouring to make is that the quality of a nerve impulse depends upon the end-plate and the nerve-cell, not upon the fibres carrying the impulse.

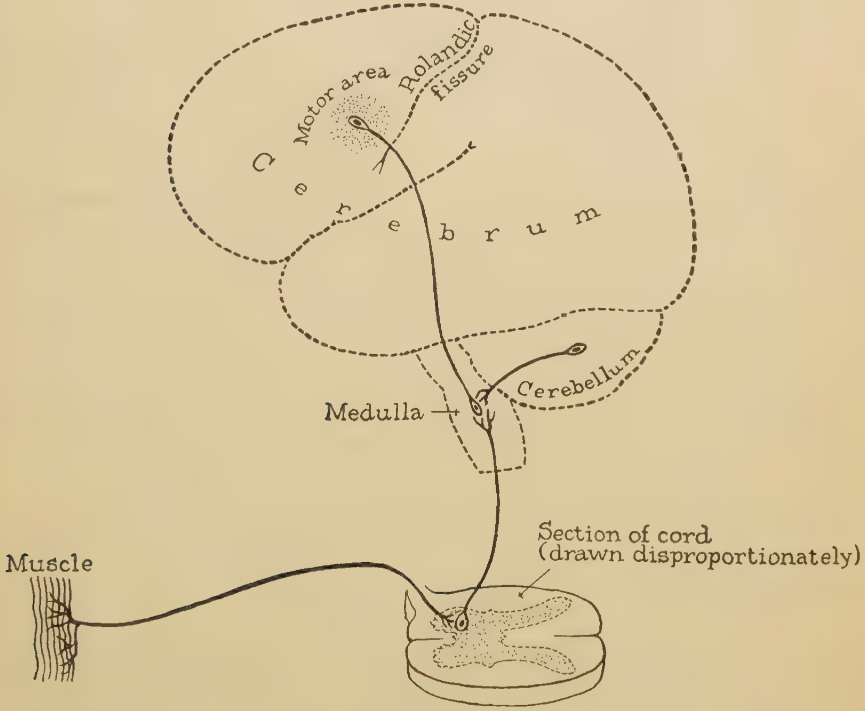


FIGURE 72

The course of a motor fibre from brain to muscle. Note that the motor tract decussates; i.e., passes from one side of the brain to the muscles of the opposite side of the body. The motor cell is shown originating in the left side of the brain, but it emerges from the right side of the spinal cord to a muscle on the right side of the body.

Our first task, then, is to inquire what the nature of a nerve impulse is — and here we are met with a philosophical difficulty. We know a great deal about nerve impulses — how fast they travel, what will initiate them, the physical and chemical environments of the nerve-fibre which will hasten or delay them — but we can only guess what the impulse itself is. The guess is that it is "the rapid passage of a wave of chemical decomposition," in the words of Watson, who goes on to say: "If a hair on the skin is touched, it is assumed that the structure and composition of the surface film (surface films must exist between two structures which are in contact) of the axons ending around the hair is altered. The state of electrical surface polarization is thus changed; and the bio-electric circuit arising between altered and adjoining unaltered regions completes the activation." But after all it is of no consequence what, in its essentials, the impulse is. We do not know what, in its essentials, an electrical impulse is, but we know a great deal about it. About the nerve impulse we know that it can be initiated and sent along a nerve-fibre by various agents — electricity, pinching the nerve, chemical substances applied to the nerve. The rate of movement of a nerve impulse is slow — about 30 metres per second, varying with the temperature of the fibre and with other factors.

If the total activity of the central nervous system is the sum of its reflexes, we must understand what a reflex is. We have already illustrated one sort. When the skin, say of the hand, accidentally comes in contact with a hot stove, the muscles of the arm jerk the hand away (Figure 73). This jerking is done immediately, long before the sensation of pain reaches what I am afraid, in spite of Dr. Watson, I must still call consciousness, and long before there can be any willing to pull the hand away done by the higher psychical centres. What happens is that the sensation of burning sweeps along the sensory nerves with such force that before it becomes known in consciousness, it overflows in the spinal cord into the motor nerves at that immediate level, causing a muscular response. Reflexes of this simple kind are used by neurologists to test the integrity of the nervous system. When you sit with your legs crossed and the physician taps you on the tendon just below the knee, the muscles of the leg in a normal person contract and cause a jerk of the entire lower leg. This is called the knee reflex, or knee-jerk. It is impossible for anyone to prevent the knee-jerk except by keeping all the muscles of his leg so stiff that no additional contraction could occur. A more complicated reflex is used by the neurologist when he throws a shaft of light into the eye; as soon as this lights on the retina, or sensory organ, the pupil contracts. This is entirely beyond the voluntary control of the individual: no amount of thinking can prevent it. These reflexes are relatively simple. They consist in an impulse applied to a sensory end organ, carried by a sensory nerve, being transmitted to a motor ganglion and carried by a motor nerve back to its end organ in a muscle, there resulting in a muscular contraction. It is possible, however, to consider nearly all the activities of the nervous system as reflexes. In the more complicated ones all human organisms will not respond alike. A shout (a sensory auditory impulse) may make an honest man turn round, a thief take to his heels. In both instances there is a muscular response, but conditioned by the kind of life each has led. Sometimes a sensory impulse is not translated into a muscular response of any kind and we must assume that a reflex of a different character has occurred. In the older days psychologists called it thinking. The sight of a lovely landscape will arouse an emotion of pleasure. The sound of music will be carried through the auditory nerve to the auditory brain centre in the temporal lobe and thence, by

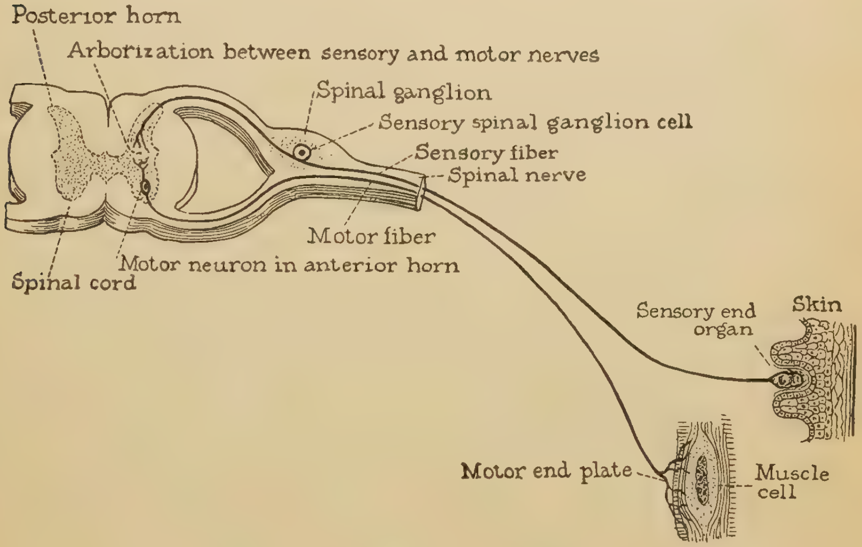

Posterior horn
Arborization between sensory and motor nerves
Spinal ganglion
Sensory spinal ganglion cell
Sensory fiber
Spinal nerve
Motor fiber
Motor neuron in anterior horn
Spinal cord
Sensory end organ
Skin
Motor end plate
Muscle cell

FIGURE 73

The reflex arc in the spinal cord. The simplest reflex, it is the conversion of sensation (from the skin) into motion (in a muscle placed near by). Follow the arc carefully from the skin (at the right-hand side of the picture) to the muscle, reading the description of the reflex arc in the text (page 232).

some process far too mysterious for us to understand, it is relayed to consciousness and memory.

In this discussion of reflexes we have always assumed that the arc is initiated by a sensory impulse. It is logical to inquire, therefore, what the nature of sensation is. There are several kinds of sensation. The old classification used to be that there were five senses. But feeling alone can be subdivided into several groups — that of temperature (the hotness or coldness of an object), of quality (the smoothness, roughness; wetness, dryness; hardness, softness of an object), of pressure and shape, and many of these are recorded by quite separate kinds of sensory end-plates. For instance, there are hot and cold nerve-endings in the skin and they are separately and peculiarly distributed. Another sense, that of equilibrium, has a perfectly distinct end organ and its own nerve pathways to the brain. So that the old classification of the five senses goes by the board.

It was pointed out above that a nerve-fibre of a certain kind could be replaced along a part of its length by a fibre of a different kind, yet the impulse would result as if no replacement had been made. In a similar way, theoretically, the fibre of one kind of sensory nerve might be spliced into that of another without changing the quality of the sensation. To be concrete, the fibres of the auditory nerve might be spliced into the optic nerve, and the eye would still do nothing but see; it would not hear. The suggestion is purely theoretical, as the auditory nerve has never been spliced into the optic nerve; the thing which would really happen would be degeneration, as we cannot experiment with these higher sensory organs safely; but the theoretical discussion will serve to make my point. Which point is that the quality of a sensation depends upon the sensory end organ where it originates and the reception area in the brain where it terminates. We know this: that if you are in a prize-fight and you get a bust on the eye, you will not feel pain so much as see visions; a person who has a tumour on his auditory nerve does not feel pain, but hears sounds. When we were discussing the effect of cathartics on the mucosa of the inside of the bowel, we said that the nerves were irritated, but that inasmuch as they carried only one sensation, that of pressure, the effect of the continued use of cathartics is simply to produce a sense of fullness.

There is a curious disease of the central nervous system, especially affecting the spinal cord, called syringomyelia; in this condition it is found that, over parts of the skin surface, the sensitiveness to touch is retained, but there are lost the sense of heat and the sense of cold. Patients with the disease may lean up against hot stoves and sustain bad burns without feeling any pain. The hot and cold spots on the skin have been carefully worked out: their number on the feet is very large, the number on the skin of the chest very small. Women could never wear evening gowns in the winter if it were not for the latter fact. Other sensations seem to have quite separate nerves — it is probable that pain is carried by special end organs. Dr. Barker of Johns Hopkins University has described his own arm; as the result of the pressure on the nerves by a cervical rib he can in some areas feel pain, but neither touch nor temperature. The tongue, being a modified piece of skin, has developed some special nerve-endings, those of taste, and this sense also is divided so that special nerves carry bitter, others sweet, sensations. The tip of the tongue conveys largely sweet tastes, the back bitter. Other fibres carry specific acid and salty sensations. The optic nerve, because it originates in the retina, can carry only sensations of sight. The auditory nerve, because it originates in the sensory end organ of hearing, can carry only sensations of sound. The eye cannot hear and the ear cannot see. We may therefore answer the question "What is the nature of sensation?" by saying that sensation is specific for the nervous end organ originating it, and the ganglia receiving it.

The integrative action of the nervous system refers to the motor co-ordination of the body. When you put out your leg in walking, the muscles on the anterior surface contract and at the same time the muscles on the posterior surface relax; when the foot reaches the ground, the reverse occurs, the muscles on the back of the leg contracting and the muscles on the front relaxing. These co-ordinative movements are laid down as automatic pathways in the brain and lower centres. The principle holds in the involuntary muscular system also — the law of contrary innervation. When a muscular contraction moves along the intestines, there is a contraction at one place and a relaxation just in front of it at every step in the progression of the wave. It has to be so, else there is no contraction wave. When the bladder contracts, the sphincter muscle at its neck relaxes.

In what part of the nervous system do all these co-ordinative reflexes centre? Probably in the cerebellum. We have seen that the cerebellum always receives a relay fibre from the sensory nerves coming from the skin and the joint surfaces, and also from the motor-nerve centres above in the cerebral cortex. Besides, it receives fibres from the eye centres and the ear centres. Of major importance for its functions, it receives fibres also from the organ of equilibrium — the semicircular canals placed near the internal ear, and consisting of three hollow bony rings placed at three levels or in three planes of the body. It is always possible for you to tell even with your eyes closed whether you are standing upright or lying on your back or side. It is doubtful if you can tell whether you are standing on your head, unless you are accustomed to doing so. All these fibres enter the cerebellum and it is a sort of clearing house for skin, muscle, and joint sense, for visual and auditory impressions, and for motor impulses.

I can best show the way in which the cerebellum accomplishes its functions by an illustration. The golf player is urged by all his instructors to keep his eye on the ball when he is about to try to hit it. Why should this help him? His eyes are about six feet away from the ball, his hands at least three feet. Why should looking at the ball help him to place one tiny space on the face of his club within one sixty-fourth of an inch of the spot on the ball which will send it the farthest and straightest? The answer is: On account of his cerebellum; because his cerebellum receives fibres from the centre of vision in the brain, from the organ of equilibrium, from the muscles and tendons of arms and legs and trunk, and from all his joint surfaces. All of these together give him the sense of space and distance, and the muscle sense of steadiness. The cerebellum also makes connexions with the motor centres, sending fibres out to his muscles. This gives him the motor sense of "placement." At no other place are all these functions of sight, equilibrium, feeling, and motion brought together.

The same thing happens with a baseball player at bat. He has to *see* the ball in order to hit it with his bat. And yet why? How does it help him to know that the ball at a certain instant of time will be just at the level of his belt at a distance of four feet, one and one-quarter inches from his body. If you told him that, you would confuse him. Yet the cerebellum makes the ten thousand calculations necessary for him to hit the ball, I will not say with unerring accuracy, because, as every schoolboy certainly knows, it is not always hit with unerring accuracy, but at least sufficiently frequently to be astonishing. Athletes need not have very good prefrontal lobes, but they must have good cerebella.

Patients with disease of the cerebellum, such as a tumour, will stagger, will be dizzy, will be unable to make purposeful movements, or movements that are accurately calculated.

The localization of function in particular parts of the brain has been mapped in two ways — by studying patients with injuries, tumours, or inflammations of various parts of the brain, and by animal experimentation. The higher psychic functions seem to be confined to the frontal or prefrontal lobes of the brain. The famous "American crow-bar case" seems to prove this. Phineas P. Gage, a foreman in a quarry, in 1848, was engaged in tamping a blast when the charge exploded prematurely, driving a crow-bar through the left side of his jaw and out through the top of his head in the frontal region. He lived for twelve and a half years after this. He was able to perform practically all his purely somatic functions, such as voluntary muscular movements, hearing, seeing, tasting, smelling, feeling, etc. But his judgment and reason and disposition were all changed and impaired. He had unprovoked fits of rage; his previously steady habits of work gave way to irregular wanderings, although he was able to hold many jobs. He became dishonest. In other words, nothing but his psychic functions was impaired. Finally he developed convulsions, and died. The brain is preserved in the Warren Anatomical Museum of Harvard University. It shows nothing but the left prefrontal region destroyed.

The motor area of the brain, which initiates voluntary movements, is in the frontal lobe anterior to a large fissure called the Rolandic fissure (Figure 74). If you open an animal's skull and with a very fine electric needle stimulate a very tiny area on the lower part of the convolution anterior to the Rolandic fissure, the animal's thumb will twitch. If a larger needle is used and a larger area stimulated, the entire arm will move. If you progress upwards, the toe will move. If a larger area at the top of the convolution is stimulated, the entire leg will go into spasm. Every time you touch the first spot you touched, the thumb and the thumb only will move. The sensory skin areas are in the region just behind the Rolandic fissure. The centre for vision is in the posterior, or occipital, lobe of the brain. The centre for hearing terminates in the temporal lobe. Below it in the uncus is the centre for smell; a fascinating syndrome called the uncinate group of fits, consisting of convulsions preceded by a period during which the victim smells a tremendous array of odours, some good, some bad, is associated with tumours in this region.

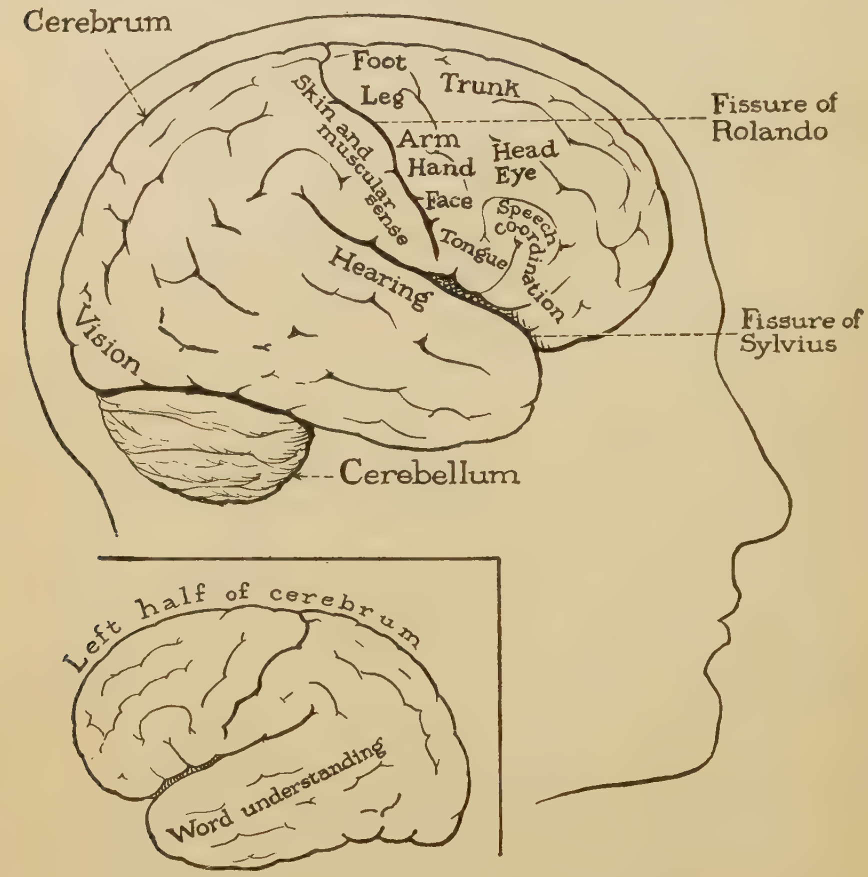

Cerebrum
Foot
Trunk
Leg
Skin and muscular sense
Arm
Hand
Head
Eye
Face
Speech coordination
Tongue
Hearing
Vision
Fissure of Rolando
Fissure of Sylvius
Cerebellum
Left half of cerebrum
Word understanding

FIGURE 74

Localization of functions in the brain.

The division of labour in the different parts of the central nervous system is of engaging interest, and will repay the wider vista of study which will be found opening in the larger literature of the subject. If the human body is the most important object of inquiry in man's universe, the human central nervous system is the part of that body which marks him off from all the other animals in that universe.

Summarizing this account of the structure and functions of the nervous system we may say that (1) it is made up of a vast number of cells, called neurons; (2) each neuron consists of a cell-body and a number of fibres; (3) one of the fibres of a great group of neurons enters the cell from an organ of sensation — in the skin, the eye, the ear, etc. — and conveys impulses from the external world to the higher centres; (4) fibres from another great group of cells go out to muscles and glands — nerve impulses going along these fibres cause motion of the muscles and secretion in the glands; (5) the other fibres of both these groups of cells and all the fibres of the other neurons make frequent contacts between contiguous cells of the central nervous system; (6) an impulse of one kind — sensation — may be translated into an impulse of another kind — motion — by such contact, the action being called a reflex; (7) the sum of the reflexes constitutes nervous activity; (8) the reflexes may be simple or far too complex for us to grasp — the reflex called consciousness, for instance; (9) the higher centres — those which receive sensations into consciousness, those which initiate motion by volition, those which co-ordinate the sensations and motions governing a complex bodily procedure — are strictly localized in certain masses of nerve-cells.

DISEASES OF THE NERVOUS SYSTEM

The nervous system is subject to the same sort of disease processes as all other parts of the body. *Infections* — such as the infection of infantile paralysis — occur, though they are less common than in other parts of the body, on account of the protected position of the nervous system; the infection of syphilis, however, very readily affects the nervous system, and there even seems to be an especial form of syphilis which settles in the central nervous system, causing the diseases commonly known as paresis and locomotor ataxia. *Tumours* frequently occur in all parts of the brain and spinal cord. *Injuries* to the nervous system are serious, because before real injury can occur to the brain or spinal cord, their bony protective covering must be fractured and this implies a serious destruction of the underlying parts. An exception to this is the injury known as concussion, in which a forcible blow stuns and even tears a part of the brain or cord without bony fracture. *Hæmorrhage* into a part of the brain, or a clotting of blood in one of the arteries (thrombosis) supplying a part of the brain, is a usual accompaniment to arterial disease and hypertension; it is commonly called a stroke, or an apoplexy. Inasmuch as the artery affected is most often that one which supplies the motor cortex of the brain, the result is a paralysis of the opposite side of the body, which may clear up as the clot absorbs.

But there are two respects in which disease affecting the nervous system differs from disease anywhere else in the body. One of these is that nerve-cells do not regenerate. Nerve-fibres will regenerate if the cells to which they are attached are intact, but nerve-cells once destroyed are destroyed for ever. Under certain circumstances a nerve-cell may be numbed so that it does not function, but after the irritation, or pressure, is removed, if it has not been destroyed, it regains its activity. Both of these things are seen beautifully illustrated in infantile paralysis. This disease is an infection which lights almost exclusively in the anterior horns of the grey matter of the spinal cord. The area of involvement may at first be widespread, so that a large amount of paralysis is at first seen. Yet the actual number of cells destroyed may be relatively few. Thus, when the inflammation subsides, it is common to see the area of paralysis diminishing so that the actual amount left after the disease is over represents only those anterior-horn cells actually destroyed by the infection. The original area of paralysis included all the parts of the anterior horn irritated by the inflammation around them.

The second respect in which disease in the nervous system differs from the same sort of disease elsewhere lies in the great variety and strict localization of the functions of nervous tissue. A boil on one part of the skin may act very much like a boil on any other part of the skin. But an abscess of the brain in the region of the speech centre is a very different thing indeed, and provokes an entirely different set of symptoms, from an abscess in the posterior occipital lobe, where the centre of vision is located, or an abscess in the cerebellum or spinal cord. It is this trait which gives to nervous diseases such a bewildering variety of manifestations.

It will, perhaps, be interesting to illustrate this and it will be easy to illustrate it by pointing out the various ways in which paralysis can be caused. Paralysis always refers to the loss of action of a muscle or group of muscles. Except in certain rare diseases in which the muscles themselves are affected, paralysis is always due to a disease of some part of the nervous system. It may be a severing or disease (neuritis) of the peripheral nerve. It may be, as in infantile paralysis, a destruction of the cells in the spinal cord from which the fibres of that peripheral nerve spring. It may be a severing, or degeneration, of the fibres going from the anterior-horn cells up the cord to the higher nuclei in the pons and medulla. In this case a different type or spastic paralysis occurs, in which, instead of the flaccidity of the muscles in peripheral nerve palsy or infantile paralysis, there is a stiffness of all the muscles. Finally the cells of the motor cortex of the brain, or the fibres coming from them, may be destroyed and paralysis of all the muscles they control result. Applying the analogy to the telephone system, your telephone (muscle) may be out of order (paralysis) either because the wire from it to the exchange is cut (peripheral nerve palsy) or because the exchange burns down (anterior spinal horn palsy) or because the wire from the local to the main exchange is cut (spinal-cord tract degeneration) or because the main exchange burns down (motor-area brain destruction).

Under certain circumstances, which we can describe only by the word "irritation," strong impulses are sent out from the nervous centres and manifest themselves in appropriate symptoms. The symptoms will depend upon what centre is irritated. For instance, we have spoken of the circumstance of a tumour growing in the uncinate gyrus of the brain and leading to the uncinate group of fits, characterized by convulsions preceded by marked olfactory and gustatory sensations. These strange odours and tastes are manifested to the patient because the uncinate gyrus is the centre for taste and smell; when it is irritated by the tumour, spontaneous sensations of that kind occur.

Two diseases, famous in history, represent this tendency of spontaneous discharge of nerve force, the one a discharge of motor, the other of sensory, impulses. Epilepsy is the name given to the first, migraine to the second. So much alike are they that it is possible to call migraine a sensory form of epilepsy. Both are characterized by periodic attacks, both are hereditary, in both the attack is preceded by aura or warnings.

Epileptic attacks consist in discharges of motor impulses, the patient throwing himself about in violent muscular contractions. It results sometimes from injury to the skull, over the motor area on one side or the other, the injury breaking through the skull and leaving scar tissue over the cells on the surface of the brain. Tumours in the motor region do the same thing. This type of Jacksonian epilepsy, named after the great brain-surgeon Hughlings Jackson, can be treated with some measure of success by surgery. The surgeon's object is to free the adhesions or remove the tumour. The majority of cases of epilepsy, however, do not fall into this category: there is no organic change to be seen in the motor cells, even under the microscope, yet the affected individual for a large part of his life is subject to attacks of convulsions. They are usually preceded by aura or warnings of some kind which tell the patient that an attack is impending — spots before the eyes, the sensation of ringing of bells, a twitching of the eyelids, or strong emotional excitement. Epilepsy may be associated with great intellectual gifts. Napoleon and Richelieu were said to have had the disease and Julius Cæsar had "the falling sickness." From time immemorial the subjects of it have been supposed to have been possessed of demons, or spirits, and their pronouncements regarded as oracular revelations of another world. In that tremendous polemic to Gladstone, Huxley showed that the miracle of the Gadarene swine, even if accepted at its face value, was a plain indication that Christ thoroughly believed in the demonic origin of disease — the priestly concept that disease is caused by the entrance of demons into the body. The treatment of this idiopathic form of epilepsy is the use of bromides or a nerve sedative — luminal. The drugs have to be taken regularly during the patient's lifetime.

Migraine, or megrim, or sick-headache, is one of the most interesting of diseases. It affects all manner of men, and particu-

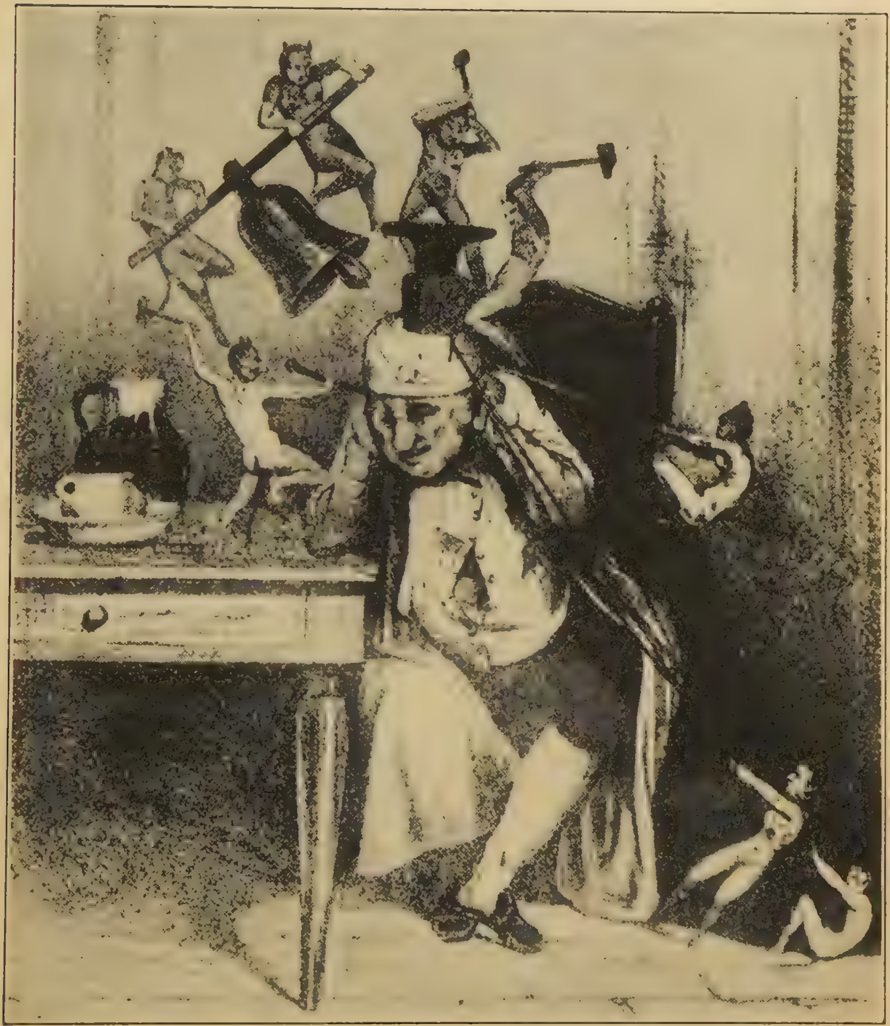


FIGURE 75

Migraine. (Cartoon by Daumier.)

larly all manner of women. Like mercy, or the fruits of science, it falleth upon the just and the unjust. Some of the most brilliant and gentlest of my professional colleagues are afflicted with it, never knowing what day will be a day of agony for them, with a torturing headache and nausea. The signs and portents which precede it form its most striking characteristics. One of my friends will have a day of euphoria, of abnormal feeling of joy and good spirits and light-heartedness, knowing perfectly well that this day always is the one just before his day of megrim. Another will sink into an unusually profound and refreshing slumber, and when he awakes to find it is an hour later than usual, he knows the deep sleep betokened the approach of his old enemy and by noon the headache will be on. Still another patient hears the distant peal of bells, of the most unearthly music, like "summer Sundays," but as their tones fade, the throbbing ache on one side of her head begins. The commonest aura are spots of light or zigzag flashes of colour before the eyes, curiously enough affecting only half the visual field. The disappearance of the attack is quite as mysterious as its approach. Something clicks in the brain and it is all over. Or a light doze before dinner marks the dividing line between agony and peace. A good stint of work in some cases drives it away: one surgeon I know will begin an operation with his attack in full blast and end it with the pain gone. It is always hereditary, Wills in one case having traced it through five generations. The attacks often stop after middle life — particularly after the menopause in women patients. There is only one way to treat it — with contempt, an old Roman remedy. Resignation is a good adjunct, now little used in the treatment of disease.

THE EYE AND THE EAR are, of all the organs of special sense, peculiarly liable to disease. Their complexity adds to the liability. It is not always remembered that they are a part of the body, made up of living tissue, and subject to all the pathologic processes which affect all the other living tissues.

The eye is an optical instrument much like a camera. The lens of the camera, which can be adjusted to the proper amount of light, is like the pupil or iris of the eye. It is a circular muscle-fibre. The photographic plate is represented by the retina, which contains the end-plates of the optic nerve, extremely complicated structures called rods and cones. Blindness may be caused by derangements of any of the parts of the eye, as failure to take a photograph may be caused by derangements of various parts of the camera. The plate may be fogged or broken: the retina may be diseased. The lens of the camera may be dirty: the lens of the eye may be blurred by cataract. The shutter may be out of order: the iris may be inflamed. This last trouble usually does not result in an entire failure to make a photograph with the camera, nor complete blindness in the eye, but it will result in a poor picture and visual disturbance.

The eye, however, differs from the camera in three particulars. (1) In front of its lens is a protective hard surface, the cornea. (2) The medium between the plate and the camera lens is air; the media in the eye, for the lens divides it into two chambers, are fluids called humours. Between the cornea and the lens, in the anterior chamber, is the aqueous humour; between the lens and the retina, in the posterior chamber, is the vitreous humour. (3) The camera brings the object into focus by changing the distance between the lens and the plate; the eye makes this optical accommodation by changing the thickness of the lens. These three circumstances lead to three other sets of derangements which may occur to the eye.

Briefly, then, we may consider the diseases of the eye under the headings of diseases of the (1) retina, (2) lens, (3) iris, (4) cornea, (5) humours, (6) accommodation. It should be said, in an introductory way, that the medical science of our time is quite complete in the department of diseases of the eye. Even Christian Scientists, I believe, recognize this by having glasses fitted after the age of forty-five and few of them are such staunch adherents of the ultimate Berkeleian idealism of their founder as to resist the urge to consult an oculist when vision begins to fail. Chiropractors and osteopaths also apparently do not consider the eye as a part of the human body, nor subject to those mysterious pressures on nerves that operate in other fields: they also wear glasses.

One of the great advances in the study of the eye was the invention of the ophthalmoscope by Helmholtz. This instrument is constructed so that light can be thrown into the back of a living eye and it has lenses so that the entire retina can be inspected. There is a passage in Helmholtz's diary which is a poem in itself;

it recalls Keats's "On First Looking into Chapman's Homer"; he writes in the day of his success: "The first model was constructed of pasteboard, eye lenses, and cover glasses used in microscopic work. It was at first so difficult to use that I doubt if I should have persevered unless I had felt that it must succeed; but to-day I had the great joy of being the first who saw before him a living human retina."

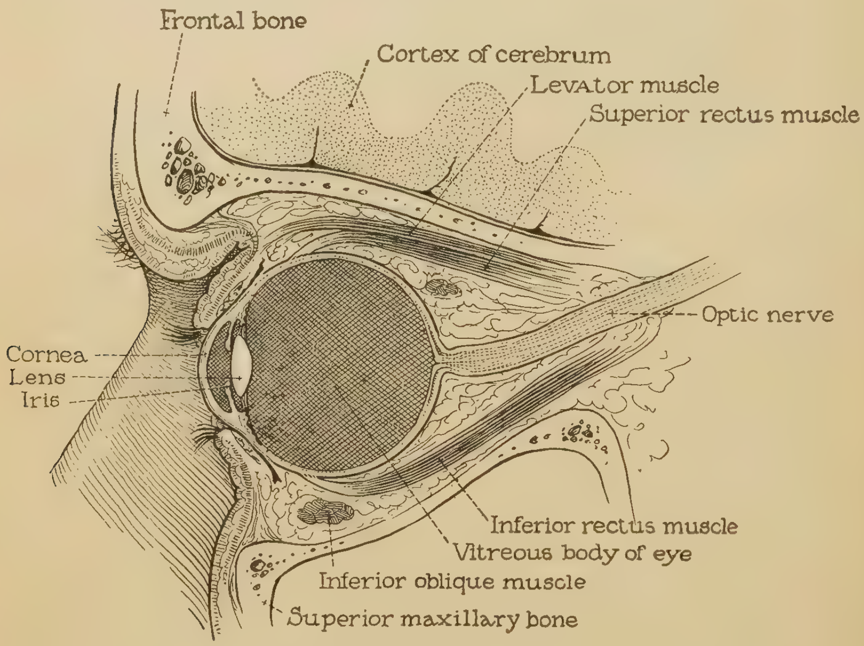

Frontal bone
Cortex of cerebrum
Levator muscle
Superior rectus muscle
Optic nerve
Cornea
Lens
Iris
Inferior rectus muscle
Vitreous body of eye
Inferior oblique muscle
Superior maxillary bone

FIGURE 76

The human eye. In cross-section.

The optic nerve being a part of the retina, it should be noted that it degenerates or atrophies, causing complete blindness. Various infections will do this, the commonest being syphilis. Indeed, the eye is particularly subject to this disease of syphilis. Hæmorrhage into the retina from disease of the blood-vessels may occur in arteriosclerosis, Bright's disease, and diabetes. Tumours may affect the retina. A peculiar disease is detachment of the retina, which a prominent oculist considers to have been the cause of Milton's blindness. Cataract of the lens is an opacity due to the deposit of material in the lens substance. It may be caused by infection carried to the lens from some other part of the body or, as in the usual form in old people, be the result of poor nourishment. In all cases its origin is somewhat obscure. Vision is restored by removal of the lens, a simple operation in competent hands. Iritis, or inflammation of the iris, tortures certain people all their lives with recurrent attacks. It is always caused by an infection, sometimes of an abscessed tooth or tonsils, sometimes an infection peculiar to the iris which goes by the name of rheumatic iritis, although what that means no one knows. The cornea, being next to the outer world, is liable to abrasion, from bits of dust or steel, to burns, from hot sparks, etc., and to infection alighting from outside. The great cause of blindness in infants, of being born blind, is an infection of the cornea by gonorrhœa. The cause of the venereal disease gonorrhœa, the gonococcus, lives well in the genital tract of the human female. A mother may be infected at the time of childbirth and the child's eyes filled with gonorrhœal pus on the way through the birth canal. Fortunately there is a certain way of preventing this scourge which used to fill blind-asylums. A solution of silver nitrate is dropped in the baby's open eye immediately after birth. All states in the Union have mandatory statutes providing for this. It has reduced the incidence of congenital blindness.

Slight optical defects in the eye, almost inevitable in a structure made of soft living tissue, are corrected by the fitting of spectacles. It is doubtful whether any one thing which man has accomplished has raised him further above the level of the beasts than the wearing of spectacles. As Clarence Day said some time ago, this being a simian civilization, and the outstanding characteristic of simians being chatter, we are likely to attach a disproportionate amount of importance to those inventions which in some way increase our ability to talk — to the telephone, the radio, the phonograph. Humbler inventions are, however, really of much greater usefulness, and none more than spectacles. Suppose a wild animal has a myopia, or short-sightedness; it cannot see the approach of its enemy, nor the exact location of its prey, and dies by violence and starvation. A modern woman with the same optical defect and intellectual purpose is fitted with glasses, and in consequence spears her prey and defends herself gallantly.

How long men have worn spectacles is a subject of some controversy among medical historians. Rivalto, a monk of Pisa, in 1305 wrote that spectacles had been invented about twenty years before. The inventor was probably a Florentine named d'Armato. On his tombstone, in the church of Santa Croce, the inscription reads: "Here lies Salvino d'Armato degli Armati of Florence, the inventor of spectacles. May God forgive his sins. Anno Domini 1317." Jan van Eyck's bishop at Bruges holds spectacles. But the Chinese have used them for countless centuries and snow-spectacles were used by the Samoyed tribes near the Arctic circle when they were first seen by travellers. Professor Greef of Berlin made an interesting discovery, reported in 1912, of the finding of eight pair of old-type leather-mounted spectacles behind the wooden wainscotting of Willibald Pirkheimer's chamber at Nuremberg. Pirkheimer, who died in 1530, was a friend of Luther's and a counsellor of Maximilian I. The lenses of these spectacles were mounted in leather and the whole appliance was of considerable weight. They had to be supported on the nose by the hand, which must have been fatiguing. They cost from $50 to $75 apiece, so that even a wealthy Nuremberg merchant must have been proud of his lay-out of eight pair.

The ear is more likely to be affected with a direct pus-forming infection than by any other disease. The infection gets to the ear from the throat. The specialty of the ear is usually combined with that of the nose and throat. The Via Appia, which binds these two principalities (these two majestic specialties) together, is the Eustachian tube. It is a short, hollow, mucous-membrane-lined tube between the cavity of the middle ear and the back of the throat behind the nose. It is designed to facilitate the act of hearing, because when sounds impinge on the ear drum, the drum must move back and forth and it could not do this were the cavity of the middle ear a rigidly enclosed space. The movement of air in the middle ear, therefore, is made free by the outlet of the Eustachian tube into the throat. The arrangement has the disadvantage that at any time a virulent throat infection may sweep up the Eustachian tube and enter the middle ear. Thus scarlet fever and measles, which both invade the throat, have otitis media, as middle-ear infection is called, for a frequent complication. A very common cause of middle-ear disease, especially in children, is an infected adenoid hanging over the pharyngeal opening of the Eustachian tube. When middle-ear infection has occurred, it may spread into the mastoid bone, which lies just behind the ear and is filled with a sponge-like set of air spaces lined with epithelium — mastoiditis or mastoid disease. The infection may spread to the large vein running above the mastoid in the skull, the sigmoid sinus; if so, a large septic clot is formed. A yet more serious complication than any of these is abscess of the brain, the abscess forming as a direct contamination from either the mastoid disease or the sigmoid-sinus infection. The prevention of this very grave chain of events is not always possible. Proper care and early drainage of the initial infection in the middle ear by a competent physician are, however, sufficient to do so in most cases.

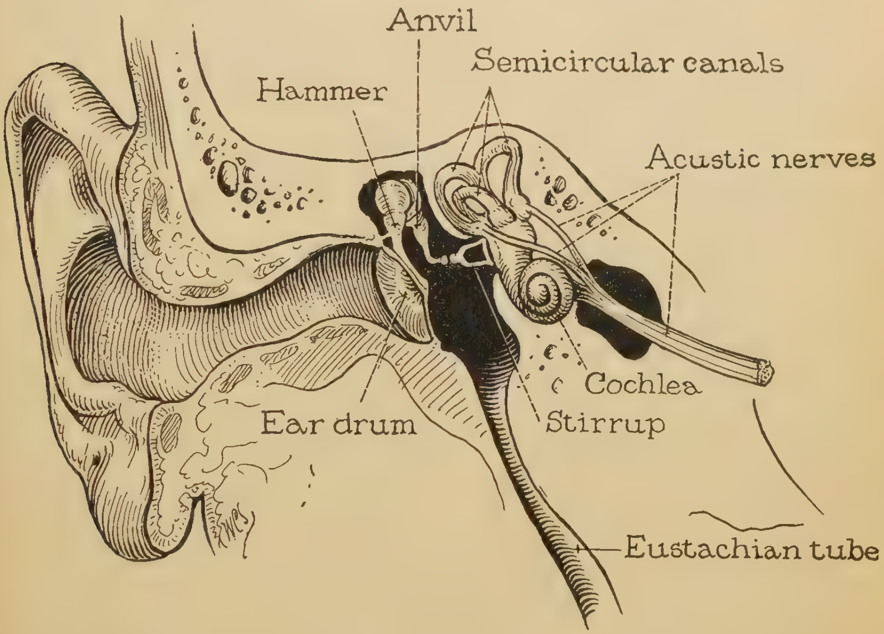


FIGURE 77

The human ear. A diagrammatic view. Note the Eustachian tube connecting with the throat. Note the close associations between the organ of equilibrium, the semicircular canals, and the ear. Note that a special branch of the auditory nerve goes to the semicircular canals.

Deafness is not often caused by acute middle-ear disease. The commonest form of deafness is a chronic sclerosis or hardening of all the tissues, drum and ossicles, of the middle ear. It may also be caused by disease of the cochlea, or internal ear, the sensory end-plate of the auditory nerve. The cochlea is like a snail-shell, with delicate hairs which respond to different wave-lengths of sound. Its study is richly rewarding. The middle ear is a most unworkmanlike structure, but no man of sensibility can stand wholly unawed in the presence of the cochlea.

The organ of equilibrium, consisting of the three semicircular canals, is anatomically close to the ear, but it has its separate nerve-track to the brain, the vestibular branch of the eighth, or auditory, nerve. The symptom of disturbance of this nerve, or of this sensory end organ, is vertigo, or dizziness. Dizziness is just as much an indication of vestibular disease as blindness is an indication of disease of the eye, or deafness of the ear. It may have several causes: it may be temporary, due to a toxic cause, the absorption of some deleterious food product. The familiar example of vertigo due to temporary poisoning is the acute alcoholic state: the reeling of the drunkard. Associated with vertigo because of their close central connexions are visual disturbances, and nausea and vomiting. Seasickness illustrates the disturbance of the semicircular canals due to too much change of position — it is really a case of overwork, as snow-blindness is due to overwork of the retina, and the deafness following a cannonade is due to overwork of the cochlea. The chief causes of vertigo when it is not temporary are focal infections and arteriosclerosis. An infection from a tooth, tonsil, gall-bladder, etc., may affect the vestibular nerve just as it affects a peripheral nerve, causing neuritis. In a peripheral nerve neuritis causes pain, but in the vestibular nerve there are no pain fibres, and, following out what we said about the nature of sensation, the result of inflammation of the nerve is disturbance of the function of the nerve, so that the resulting disturbance in the case of vestibular neuritis will be vertigo. The removal of focal infections will clear up most chronic cases of the disorder.

CHAPTER XI

THE RELATIONS OF MIND TO BODY

In that same third chapter of *Marius the Epicurean* which I have already quoted, there is a phrase to the effect that Marius hoped "that all the maladies of the soul might be reached through the subtle gateways of the body." A curiously twisted mistake even for an Oxford don to have made. For the truth lies at exactly the opposite pole, and the maladies of the body are far more likely to be cured by attention to the *salus* of the soul. By this is not meant, naturally, any acknowledgment of the validity of such unctuous explanations as those associated with the doctrines of Christian Science. I do not believe that matter is mind or that mind controls matter. What is meant may be put in the words of a widely experienced practitioner to whom I said that I believed at least fifty per cent of the patients he and I saw had no organic disease, but were sick because their minds, their souls, their lives were warped.

His reply was: "Eighty per cent."

In short, an ulcer of the stomach cannot be brought about by a state of mind or a state of emotion; but a pain in the abdomen, not unlike the pain of an ulcer, can be brought about by either a state of mind or a state of emotion (fear).

Examples of this fact are everywhere to be observed. Conspicuous are the medical miracles of Jesus. With a few exceptions — the woman with the issue of blood, Peter's wife's mother, who lay sick of a fever, the healing of the ear of the servant of the high priest, and the healing of the various sets of lepers, about all of which cases the accounts are ambiguous — all of Christ's cures were made upon people who were plainly hystericals. The very catalogue of them — the man with the withered hand, the man blind and dumb from birth, the boy possessed by demons, the trances of Lazarus and Jairus's daughter, the man who was let down through the roof and who afterward took up his bed and walked — smacks of the roster in any neurological ward. Cures of such cases are made daily in the general hospital at Waco, Texas.

The literature of saintly biography is full of the same sort of thing. "Antonio de Miranda," avers the biographer of St. Francis Xavier, "was going one night on business to Courbature, when he was bitten by a venomous serpent. He immediately fell down as though paralysed and became speechless. He was found thus lying unconscious. Informed of the fact, Father Francis ordered Antonio to be carried to him; and when he was laid down, speechless and senseless, the Father prayed with all those present. The prayer finished, he put a little saliva with his finger on the bitten place on Antonio's foot, and at the same moment Antonio recovered his senses, his memory, and his speech."

But one need not go either to ecclesiastic or secular literature to convince himself of the truth of this idea. One need not read at all. Surely everyone can recall one or two friends who have complained all their lives, and have lived all that time in the most perfect condition of health.

They are inclined to have "fashionable" diseases. In 1885 they had too much uric acid. In 1890 they had chronic appendicitis. In 1895 they took the Kneipp water-cure. In 1900 they had floating kidneys. In 1905 they had tilted uteri. In 1910 they had colonic stasis. In 1915 they had all their teeth extracted. In 1920 they had non-surgical biliary drainage. In 1925 they had an inferiority complex.

One of the chief difficulties in the way of an adequate explanation of these phenomena lies in the lack of a term to express what is meant by the word "*mind*." The patients themselves are particularly likely to resent the employment of such diction. "Do you believe that all this is simply in my mind?" they will inquire, obviously bridling. The "mind" is supposed to be a cold, calculating organ of reason. How can it possibly run so far amuck as to get them in this state? To say that the condition is "emotional" is not to better the situation any, and is distinctly incomplete. All of these terms are likely to bring up the fatal word "imaginary." And that is resented more than anything. "I can tell you this is not imaginary," they will say and they are perfectly right. The conditions are the sum of the individual's whole life and experience up to that time. They are the result of his adaptation to the facts of his life.

Let me illustrate the matter by choosing an example entirely outside the realm of disease. I am sitting with some friends quietly on Sunday evening. One of them goes to the piano and begins to play. One or two others gather round and a song is sung. On such occasions familiar and simple and sentimental songs are likely to predominate. Finally an old hymn is begun, "Onward, Christian Soldiers," and I arise and join in the singing. Why do I do it? Not to exhibit any virtuosity: I have no voice, and no ear; my contribution is an almost inaudible mumbling. Not because I subscribe to the statements made in the song. I do not believe that "Hell's foundations quiver" at any "song of praise," nor, if I did, should I be inclined to bring about so drastic a rearrangement of cosmic balance. I certainly do not believe "we are treading where the saints have trod" and would be particularly uncomfortable were I doing any such thing. Not because I believe I am being made better or establishing any good marks in any celestial ledger: on the contrary, I believe my action is as nearly without consequences as any action can be, and as nearly divorced from what is ordinarily called right or wrong. Yet I do join in the singing and derive a great deal of pleasure from so doing. Why? Well, for so many reasons! You see all my life culminates and focuses for a moment at that point. I do so first because I am in possession of my faculties and can recognize the tune, know that I have some recollection of the music and can, in a way, join in. I do so because I have a friend who can play and who is playing this old hymn. I do so because it gives me pleasure to do what others are doing. I do so because it gives me pleasurable emotional recollections of singing this hymn as a child, of singing it with other groups of friends, some of whom I loved and some of whom I shall never see again. And finally, perhaps, because it gives me a naïve happiness to experience vicariously the feeling of the innocence and faith of childhood. If some one were to say to me: "You don't want to sing 'Onward Christian Soldiers'" (corresponding to the physician's statement to the neurotic: "You haven't a stomach-ache"), I should answer quite vehemently that I did.

The patient with a psychoneurosis is somewhat in this condition. The victim of obsessions — the man who must touch every lamp-post as he moves along the street — or of morbid fears or phobias — the woman who thinks she has committed the unpardonable sin, or the person who has consulted a fortune-teller and who comes to believe that the fortune-teller has acquired a power over his actions — or of behaviour disorders — the man who has got himself at odds with his wife and sons, wrapped up in a coagulum of hate and frustrations, with all his sensory end-plates pulled in like so many tentacles, so that he can never enjoy a painting or a play or a novel or an hour at the microscope — all of these people are doing what they are doing because their whole life has led up to that set of thoughts and actions. In the case of the fortune-teller phobia, the fortune-teller may accidentally have happened upon some statement which brought up vividly an actual incident, and an extremely painful one of early life, forcing the conviction that there was some supernatural insight at work. In the case of the man at odds with his family, the experience of childhood, of a drunken father sneering at the adored mother, may give the entire direction to after life. Each of us has the windows of his house built for him by experience, and we can look at life through no other casements.

The examples chosen are distinctly on the psychic side of life. What is far more difficult both for the average layman and even for the physician to recognize is that there are physical conversions of the same sort. Chronic dyspepsia, palpitation of the heart, constipation, headaches, fatigue (a particularly notable example), insomnia — all of these may be, and, in the list just given, usually are, present not because they represent the symptoms of a disease process, but because they represent the adaptation of the patient to his life up to the time of their origin. This is a particularly important point, and one which I wish to emphasize in the strongest terms. As I go about my activities in the world, I find no feature of life of equal importance, both as to frequency and significance, so generally overlooked or even so positively rejected. The causes of this neglect or rejection may be placed in two categories: the reasons for rejection by the layman, and the reasons for rejection by the physician.

The layman's reasons, or rather, since it usually comes down to that, the patient's reasons for rejection of this doctrine that physical symptoms can arise from psychic states are several. The most potent of all is one very difficult for the outsider to grasp — that the patient is totally unconscious of the steps by which he got sick. It seems quite incredible to bluff common sense that a woman would keep saying her food did not digest if there were absolutely nothing the matter with her stomach: and when the physiologist is able to point out that this symptom lets her off from the housework which she detests, her husband arrives at the almost inevitable conclusion that she has known perfectly well that was why she was doing it and should be spanked. Yet the paradox is that she does not know consciously anything of the sort.

An illustration which I have used many times is the psychic state of stage-fright. An inexperienced actor walks upon the stage with the purpose of announcing: "There is a dead body under the sofa." He faces the audience and becomes speechless. Please note for purposes of parallel that he is suffering from a purely physical disability: he cannot move the muscles of his larynx. Two explanations might be brought forward; both of them are the explanations which the husband of the dyspeptic woman held at one time or another. One is that the actor has an organic disease, that the muscles of the larynx are paralysed. The other is that he is refusing to speak out of pure devilment. Neither is true: the muscles of the larynx will soon be working perfectly, and the unfortunate Thespian is more anxious than anyone to make his startling and lugubrious disclosure. He would be the last person able to explain why he cannot pronounce the fatal words. This unconsciousness of the mechanisms of the process, a fact which has been insisted upon by all the students of psychotherapy, is one of the most difficult of its fundamentals to appreciate.

The second most potent factor in the failure to realize the nature of the difficulty lies in the similarity between the symptoms experienced and the symptoms of actual organic disease. Headache is so common in all organic diseases — fever, high blood-pressure, nephritis, exophthalmic goitre, nasal disease, eyestrain — that the conclusion becomes inevitable that if a headache is present, *some* organic disease must be behind it. Discomfort in the stomach is known to be associated with ulcer of the stomach, with gall-bladder disease, with cancer of the stomach; and if it is felt, something must be the matter — something tangible which can be seen, felt, and appreciated. The patient is thoroughly imbued with the idea that there is some doctor somewhere who can do something, can give him some magic herb which will furnish permanent relief. And so they go from doctor to doctor, from health resort to health resort, from treatment to treatment, from operation to operation. The "chronic" appendix is removed, the gall-bladder ("filled with thick, inspissated bile") is drained, the womb is straightened, the kidney is sewed in place, the nose is reamed out, the teeth are extracted, and the adhesions are loosened. But it is no sudden tour de force, no piece of magic, no incantation which will cure them; it is a patient, slow, laborious digging out of the psychic pattern at the root of this organ fixation (or physical conversion, whichever term you wish to use).

More and more patients, after they have made the dreary round of the specialists and mechanists, are to-day finding relief for such afflictions from regular physicians who devote themselves to rational psychotherapy. They have been too intelligent to be able to accept Christian Science or the plans of suggestion-mongers like Coué, but fortunately the medical profession has, even if belatedly, turned its attention to their needs. Not all of the profession, however; in fact only a fractional representative portion! But enough so that we are able to say that medicine has to-day within its own boundaries means for the treatment of this class of patients, that they need not depend, as they have in the past, on ignorantly born and inefficient and incomplete methods of psychotherapy.

It must be acknowledged, however, that the medical profession as a whole not only does not use psychotherapy consciously to any extent, but is even very resistant to the general doctrine outlined in the first paragraph of this chapter. The reason for this attitude of mind lies largely in the training of the average physician. All his professional life he is urged to look upon disease from a mechanistic view-point. He has learned so frequently that obscure disorders which have puzzled him can be explained on the basis of chemical change, or tissue change, or change consequent upon the invasion of the body by bacteria, that it becomes an ingrained habit of mind. Therefore when a patient with many symptoms and no signs appears, he is apt to think that, no matter if you do call it hysteria or neurasthenia, still there must be some obscure infection, or some derangement of a ductless gland, or some metabolic disorder temporarily beyond his powers of demonstration which perverts the psyche of his patient in this peculiar way. When the patient's complaints become so absolutely unreasonable as to force him to the conviction that no physical basis for them exists, the spiritual equipment of the average practitioner is inadequate to a sympathetic interpretation. He seldom arrives at any but the simplest psychologic explanation of the disorder, the favourite being that the patient acts peculiarly from pure deviltry.

It is this astigmatism on the part of the profession which has prevented it from developing an adequate method of psychotherapy. The methods of psychotherapy in use up to a few years ago were thoroughly stupid. The rest-cure, the use of baths, nerve tonics, placebos (or in other words pills having no pharmacologic action), crude methods of suggestion, such as patting a patient on the back and saying: "You'll be all right" — what could be expected from them? At best the theory of their use was mechanistic — that when the body was improved, the mental state would be correspondingly improved — and depended largely upon the belief that time would bring relief. To a certain extent this is true, but the methods were crude, the relief was incomplete. And so for years the unsympathetic attitude and lack of understanding, or even attempt at understanding, on the part of the medical profession drove these patients into the Christian Science Church, to religious healers, to mountebanks and quacks.

It is with the conviction that this is no longer true, with the belief that the medical profession has developed within its own ranks a scientific and effective set of methods of psychotherapy, that I venture to call attention to the somewhat reactionary attitude which previously existed and to a certain extent still persists regarding the subject. The methods referred to are largely associated with the name of Dr. Sigmund Freud of Vienna. Of the enormous fabric of speculation associated with his name, and of the embroidery worked upon it by Jung, Adler, Ferenczi, and others, I do not propose to attempt, in this place, to make an abstract. Those doctrines have repeatedly been presented to all intelligent persons. That they have to a large extent suffered from unwise exploitation and immature interpretation there is no doubt. For that reason it may be permissible to make one or two general statements about them.

There have recently been put into print in the magazine and newspaper literature of the day a number of somewhat contemptuous and slighting references to the subject of psychoanalysis and Freudianism. The general trend of such remarks is to imply that the belief in the Freudian generalizations is a fad, and that like all fads it appeals only to unstable enthusiasts and is based upon inadequate observations.

Such an attitude, and I say this from the standpoint of the general practitioner who has actual problems to solve, who has seen the system in operation, and who knows something both of its failures and accomplishments, is totally unfair. That Freud himself had certain grave temperamental defects is quite true; but these have by no means vitiated the solid substance of his work.

In the first place he made the greatest advance in human psychology which has been made since it became a science. He swept aside all those solid compartments into which the older psychologists had placed the different divisions of the mind — will, memory, perception, thought — and demonstrated that the mind reacts to experience as a unit. He made synthesis of the mind, and destroyed at one sweep those categorical conceptions of mental aberrations such as are embalmed in the old treatises, for instance of Ribot, "Diseases of the Memory," "Diseases of the Will," and in the analytical codification of Kraepelin. These ancient conceptions had shackled and deadened both psychology and psychiatry.

Freud's ideas, in the second place, have been enormously fructifying in many fields of research. Men who had been breathing sluggishly in the dead air of Kraepelinistic classification suddenly found that minds were alive: that they were moving, that they were dynamic and not static. The influence went out beyond the confines of medical practice, of psychology, of psychiatry, to all human activities. A whole new science of folk-lore, of anthropology, of archæology, of history, is being builded round the ideas developed in the Viennese clinic. Literary criticism, artistic criticism, painting, and music take on new values from an interpretation in the light of Freud's doctrines. When the idea of evolution in organic life became known, its stimulating power was felt in widely divergent fields. In economics, in sociology, in history, in philosophy, in astronomy the effect was as if men suddenly saw all the facts of their subject anew. Freud's doctrines have done this same thing — certainly the most interesting thing any system of thought can accomplish.

That there are defects in the general theory no one will deny. Certain of these, as has been hinted, are due to the temperament of the originator. Freud is one of the obscurest writers who ever lived; it is torture to observe him writhing on paper. He had no gift of expression: Jung has always been the phrase-maker of the movement. The insistence on the influence of sexual experience led to an unfortunate attempt at unitarianism in the doctrine. It crystallized in the statement that all disturbances in the life of the spirit are due to maladjustments in the sex life. I think it is now generally agreed that if any unified expression of what has been learned can be made, it must state that such disturbances are due to interference with the full development of the individual's personality and ideals, no matter what the cause. Freud's insistence on the importance of dreams as revelations of the subconscious life has opened a number of effective objections. One of these is the belief that the patients in question, being notoriously unstable, and suggestible, have in the waking period filled in those parts of the dream which became evanescent. To this the psychoanalyst replies that he is always on the look-out for such substitutions and that, even if they are made, they are just as significant for purposes of revealment as the dreams themselves. The anonymous author of the "Confessions of an Ex-Psychoanalyst" (*New Republic*, March 24, 1926) says that when he discussed the interpretation of his patients' dreams with a group of other psychoanalysts, none of their interpretations agreed. Such lack of standardization is probably inevitable and will always prevent psychoanalysis from becoming an exact science. But this is not to be deplored. A too exact science of psychology would be the last straw to make life thoroughly unbearable. As for the objection the ex-psychoanalyst made to multiplicity of interpretations of a dream, it would seem to me more than likely that all dreams, far from having only one meaning, are freighted with thousands of connotations.

The criticism, however, brings us upon a peril to which the Freudian system and the Behaviourist psychology, which I must regard as its offspring, are both subject. They are solidly mechanistic. And while it is probable that mental processes are mechanical, the data to prove this are not as yet accumulated. In practical dealings we must leave something over in the margin. When Dr. Watson insists, as he frequently does, that the Behaviourist psychology is the only scientific and complete explanation of mental processes, we must beg leave to reply as Dr. Johnson did when Boswell suggested that they elect some new members to the club because "we have pretty well travelled all over each other's minds":

"Sir, you have not travelled all over my mind yet, I assure you." The Behaviourists have not travelled all over my mind, I assure them.

What the Freudians need more than anything else is to acquire one or two poet-minded interpreters. I merely drop a hint. One of their favourite complexes is Narcissus, who found his own image in the river so lovely that he became enamoured of it and finally fell into the water and was drowned. Frank Harris tells of one of Oscar Wilde's improvisations, that the flowers of the field asked the river for water that they might weep for Narcissus. The river replied that all the water of the sea was not enough to weep for him. And the flowers answered: "Oh yes! was he not lovely?" "That I can not recall," said the river. "Why, did you not see how beautiful he was as he hung over you?" asked the flowers. And the river said: "No, all I saw as he hung over me was, in the clear deeps of his eyes, the vision of my own loveliness." That is what I mean by leaving a margin in the study of these cases.

Twenty-five years ago the psychoneuroses would have been neatly classified as (*a*) hysteria, (*b*) neurasthenia, (*c*) hypochondriasis, (*d*) phobias, (*e*) impulsions and obsessions. These last were on the border-line and beyond them lay the realm known definitely as insanity. There was a wall which marked off the one from the other, and the person who passed over into insanity crossed a very definite and rigid mental boundary mark. The test of his passing was whether or not he had lost a portion of his equipment called responsibility. If he had it, he was not insane; if he did not have it, he was. It was all very simple.

More and more to-day students of insanity are coming to the belief that those forms which were called paranoia and dementia præcox, and maniac-depressive are hardly to be distinguished from the neuroses. That if one studies a case of this kind, the stages of development of the mental aberration are a slow progress in which it is difficult for anyone to point out any one spot beyond which the man is insane, and before which he was sane. Thus the older conceptions of insanity are passing away and it is, I think, fair to say that the use of the word is obsolete. This particularly applies to criminal procedure and to the interpretation of the word "responsibility." A sign of the times is the intensive joint study of the criminal procedure by representatives of advanced psychiatric thought and of the American Bar Association. The purpose in the future criminal trial will be to study the criminal, not to judge him.

It may be interesting, since we are concerned here with the psychoneuroses rather than the psychoses, to glance at the definitions furnished by the older classifications. All of them, it should be pointed out first — both the psychoneuroses and the psychoses — have a strongly marked hereditary tendency towards what we must call an unstable nervous system — towards an organization inadequate to the storms and demands of life. And, of course, the hereditary nature of the imbecile and idiot strain is well known from the studies of the Jukes and the Kallikak families.

Hysteria has such protean manifestations that it would seem impossible to create a definition at once inclusive and adequate. In one form of it the patient throws herself — it is usually, though not always, a she — into a rigid semicircle supported on the bed or floor by the heels and the back of the head. In another form the patient is unable to see one half the field of vision. In another there is a paralysis of one arm. In still another there is an anæsthesia of one arm, so that pins can be stuck into the flesh. In yet other forms, the patient will wander away from home for long periods; the mind a blank as to the former life, though under a different name business affairs are conducted with complete responsibility. This is closely related to the split personality types of Jekyll and Hyde, many of which have been carefully studied. Pierre Janet, in one of the most absorbing books I know, *The Major Symptoms of Hysteria*, has proposed a definition of hysteria which is comprehensive and which reconciles all these protean manifestations. He calls hysteria an *amnesia* — a forgetfulness.

It is a shutting off of a certain part of the mind. The split personality in the simplest form for a time forgets the part of itself that is "good," or later the part that is "bad." There is, for instance, a curious thing about the paralysis of hysteria, which is that the paralysis does not affect a path of nerves but affects a mental concept, such as an arm. Similarly in anæsthesia, say of a hand, the anatomical arrangement of the sensory nerves to the hand sends one nerve to the area of the little finger and half the next finger, and another nerve supplies the palmar surface of the other fingers and thumb, while still another supplies the skin over the thumb side of the back of the hand to the middle of the ring-finger; it is seldom that in actual organic disease of these nerves all three are affected at once; but in hysteria, the anæsthesia stops in a ring around the wrist: the hysteric "forgets" the hand, the mental conception of *hand*. Thus all through the list of symptoms it can be shown that hysteria is an amnesia.

The new morbid psychology accepted this definition and encompassed it, but pointed out that such a study threw no light whatever on the origin of the mental state. It went to work on individuals and dug out of their life histories the subconscious mental processes which had been at work.

For neurasthenia a perfectly simple psychologic state was evolved. The nervous system was tired: it was worn out. It needed to be rested. The brains of animals which had been forced to run round cages and go without sleep were put under the microscope, and the brain-cells were shown to have more granules in them than the brain-cells of animals which were not fatigued. This demonstration was, like Dr. Crile's specimens of the "kinetic drive," simply an example of bad histological technique. The "storm and stress" of modern life was evoked to explain the fatigue of the nervous system. But certain very important things were overlooked, one being that the people who were most subject to this asthenia of the nervous system were those who never did anything the least bit fatiguing. It was not the captain of industry, with a thousand interests, worries, and responsibilities, who had neurasthenia. It was his wife, who breakfasted in bed and dressed only in time to get into a game of bridge. It was not the ditch digger working hard every day with an ever increasing family to support, but the young gentleman of inherited wealth who had just returned from a cruise of the Mediterranean whose nerves were all fatigued and granular. As for the stress of modern life, there has never been a time in the history of the world when life was so easy, when less work commanded a greater reward than now. If you do not believe so, think of the situation of the modern man, whose civilization has so solved the problem of distribution that he can buy at the next corner wheat flour from Canada, beef grown on the Texas plains, bananas from the West Indies, wool cloth from sheep raised in Scotland; compare him with the Neanderthal man, grubbing his livelihood from the forests and streams and ever on the alert for the sabre-toothed tiger or the woolly rhinoceros. It was in those days that the storm and stress of life were real.

The phobias and the impulsions are truly on the road to complete mental deterioration. Yet their origin is of precisely the same sort as the maladjustments to life which result in hysteria and neurasthenia. It must always be remembered, however, that the neurosis itself may be an adjustment: it may be the individual's solution of his problem. Just as a crime may be, and often is, the criminal's solution of a life problem. He needs money: that is his problem; he steals it: that is his solution. Phobias are morbid fears — fears which have no reasonable basis. Impulsions were, according to the old classification, a disease of the will: the commission of acts, or the impulse to commit acts, which have no reasonable basis.

Hypochondriasis is the condition of having symptoms which do not rest upon any discoverable organic basis. Notice that I was very careful not to say that the hypochondriac *imagined* he had certain diseases. That conception is very old — as old at least as Molière, who named his study of it *Le Malade Imaginaire* — but, as I have tried to point out above, it is far too simple an explanation. The psychologic state of hypochondriacs is never simple. Sometimes it is a long tangled misadventure which is at bottom a fear of death, a fear of extinction. Freud concentrated his attention on those neuroses which depend upon a lack of adaptation in the sphere of the sex life. He said that theoretically there might be other conflicts, but in his own experience sex conflicts were behind all the psychoneuroses he examined. But there is an old proverb that self-preservation is the first law of nature, and the hypochondriac has been shipwrecked on that rock. Sometimes it is an escape: an escape from duties, from labours which are distasteful or in which the patient has failed; a person who is sick cannot work, cannot go to school, cannot assume the obligations of contact with the world. Sometimes it is due to an abiding childhood experience: the dyspeptic who has watched her father taking digestive pills before and after every meal, and has grown up with the belief she has a "weak" stomach. Usually it is a combination of all these things, and almost inevitably has its roots deep in early life — in the impressions of childhood.

Perhaps an example from actual experience will make the point clear. An orthopædic surgeon referred to me a woman who complained of weakness and pain in the back. X-ray pictures and careful physical examination had been made. There was a very slight deviation of the vertebræ in the lumbar region. This, however, could hardly account for the great disability complained of. A goodly proportion of the population has this much spinal curvature without knowing it or having any symptoms from it. Focal infections, if any, had previously been removed. My own examination was negative and I set myself to try to find a way to get her interested in something besides her back. She lived in a small town where social and intellectual interests and entertainments were few. She was able to play golf, but admitted that it did not fill her life. She had been married three years and had no children. I suggested to her that the interests of a child might be a source of satisfaction to her. She seemed quite astonished at this, saying that she did not see how it was possible for a doctor to advise her to have children with such a back, that she would not be able to carry a baby round, even after it was born. When I averred that I believed her back would stand it, she left me in anger and disgust. She returned, however, a few days later to say that she had thought of adopting a baby, and to ask my opinion of this solution. I pointed out that an adopted baby would have to be carried just the same as any other and would be equally hard on a weak back. I will not go into the long process of untanglement which ensued. Beginning with the statement that she was sure she should die if she attempted to have a baby, I discovered that, when she was very young, her older and favourite sister had died in childbirth and all the events connected with this tragedy had made so deep an emotional impression on her that all thought of childbearing was terrifying to her. It should be remembered, however, that so painful had been the associations of her sister's death that she largely thrust them into the subconscious. Her back was a transference protective device.

To these conditions simulating organic disease the orthodox psychoanalysts have not given the attention which they deserve. They constitute a very large numerical group. Their unhappiness is very real. They are treated by the regular medical profession with a stupidity which is simply appalling. The complacent indifference to, not to say satirical enjoyment of, their sufferings, is now, as it has always been, the most vulnerable spot for criticism of medicine. The failure to discover the nature or relief for cancer has been an honest failure: the attempt has been made with every means at command; and quite honestly it is acknowledged that we know very little about the subject. In the case of the neuroses, however, the means of understanding and treating them have been present; it has simply been our indifference to their significance and our spiritual smugness which have signified to the world our unwillingness to assume larger duties.

Dr. Tom A. Williams of Washington has set down a series of beliefs commonly held and commonly leading to unhappiness. None of them are true. He calls them:

"Popular Misconceptions about the Body"

"1. Eight hours' sleep is essential to health. All insomnia is dangerous and incompatible with health. Nervous insomnia leads to insanity.

"2. Overwork leads to nervous break-down. Fatigue accumulates from day to day and necessitates a long rest for recuperation.

"3. A carefully planned diet is essential to health, especially for the nervous person. A variety of food eaten at the same time is harmful. Acid and milk — for example, oranges and milk — are difficult to digest. Sour stomach is a sign of indigestion.

"4. Modern life is so strenuous that our nerves cannot stand the strain.

"5. Brain work is very fatiguing. It causes brain-fag and exhaustion.

"6. Constipation is at the root of most physical ailments, and is caused by eating the wrong kind of food."

PART III

THE HUMAN BODY AS AN ORGANISM FOR THE REPRODUCTION OF ITS OWN KIND

CHAPTER I

GENERAL BIOLOGY OF REPRODUCTION AND SEX

To reproduce a new and distinct human body requires the co-operation of two other matured human bodies, differing slightly in structure from one another and known technically among biologists as male and female.

On the whole it seems rather a clumsy arrangement. It is difficult to discover any unusual perspicacity on the part of deity in such a scheme. It does not, moreover, appear to be an inescapable rule of biology. A unicellular organism regularly reproduces another individual by the simple expedient of dividing into two. Even much higher up in the structural tree such animals as the sea-worm, *Planaria maculata*, are able to reproduce or at least regenerate after being divided either horizontally or vertically, each half regenerating a head, a tail, or another eye as the occasion demands. (For illustrative diagrams see Figure 78.)

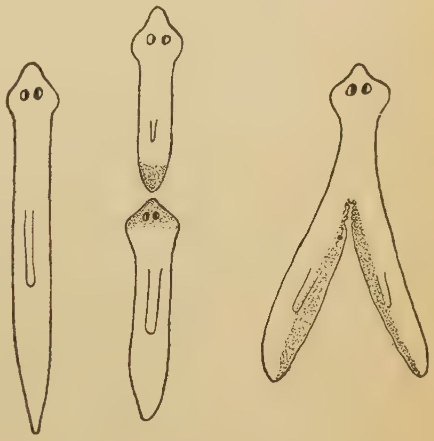


FIGURE 78

Reproduction, or regeneration of new individuals, after dividing the sea-worm Planaria maculata. (After Curtis.) The normal worm shown at left. In centre, two new individuals formed after worm is cut in half. At right, new parts forming after longitudinal division. Regenerated areas shaded.

Among vertebrates, of course, such things do not happen at all. Among vertebrates the absence of the necessity for male parents is found only in research laboratories and the Gospel according to St. Luke. Jacques Loeb was able to fertilize with chemical salts the eggs of a female frog, so that adult living frogs resulted. The explanation of this, as advanced by competent biologists, is that to fertilization there are two elements. When the sperm, as the male element of reproduction is called, enters the female element, the ovum, it brings first its contribution of nuclear chromosomes and secondly a chemical change somewhat as if it were a catalyst. Previous to fertilization the egg membrane is very impervious to any salts in the medium surrounding it. The entrance of the sperm seems to allow certain salts to enter the egg cytoplasm. It is these salts, rather than the union of the chromosomes of sperm and ovum, which initiate the rapid growth and multiplication of the germinating cells. By changing the chemical content of the solution in which the frog and sea-urchin eggs were kept, Loeb could instigate a development unquestionable, but never imitated in nature.

Nature seems certain, however, that the plan of having two parents is a success. And we must try to explain or understand the advantages which her experience has taught her. One reason suggests itself immediately. In a wild state the danger to any animal's life is constant and imminent. If the destinies of the unborn individual were invested in one animal and that animal killed, the next generation, so far as that unit was concerned, would be completely wiped out. As it is, the male can guard the female, bear the brunt of any attack, even be destroyed, without affecting the unborn at all.

The great advantage of bi-sexual parentage, however, lies in the enormous possibility of variation. A single individual reproducing passes over to its offspring only its own somatic characteristics. A terrific monotony would result. But with bi-sexual parentage the male element, the sperm, as well as the female element, the ovum, bears all the possibilities of all its ancestors in its chromosomes. These divergent strains joining are bound to result in fresh and new combinations which furnish a constant set of variations, upon which natural selection can fasten.

Mammals, to which class the order of primates, including the species man, belongs, are distinguished by the facts that during the early stages of development the offspring is harboured inside the body of the female in an organ called the womb or uterus, and that after it is extruded from the mother's body, the mother nourishes it by elaborating a nutritious fluid, milk, in certain glands, the breasts or mammæ. This general plan has been much praised and is supposed to represent a great improvement over other methods of reproduction in the animal kingdom and a particular solicitation towards man and especially woman on the part of that force external to ourselves which makes for righteousness. I am not sure that such praise is entirely deserved. The most sensible arrangement, I submit, is that developed in another branch of the tree of evolution — the birds. If I were picking out the animal mothers which seem to have had the advantage of the greatest amount of foresight on the part of that force external to ourselves which makes for righteousness, I should most unquestionably give my vote to an egg-laying order. The hen, it seems to me, has it all over the woman in this respect.

The hen is able to extrude the fertilized egg from her body with no more discomfort than arises from the writing of a sonnet. From prevalent complaints on the subject which reach me from time to time I deduce that this is a distinct advantage over the human manœuvre. Nor is this virtuosity of the hen's attended with any decompensating lack of efficiency in the product. Her egg after extrusion is endowed with the ability to develop and produce an individual quite as complex as any human prototype: its liver when put under the microscope has cells and structure as intricate and praiseworthy as the liver of the infant daughter of a congressman. Its eye can hardly be distinguished from a human eye; it has retina, iris, rods and cones, sclera — all the same, all equally perfect. It is true that there are more creases in the brain of the human infant than in the brain of the chick, but in rebuttal it can be advanced that there are more feathers on the chick, and whether one is more important than another is distinctly debatable. Plainly, however, argument is useless: the human female is a mammal and not a bird, and there is no way to change her methods of reproduction. But equally plainly, however superior we may feel about other instances of omnipotent grace so far as our structure and function are concerned, there is no use in assuming an air of false pride and pre-eminence over the hen in the especial matter of our divergent modes of reproduction.

Platitudinous as these statements may seem and indeed are, they nevertheless are, and always have been, fraught with a deep significance to the human race, particularly on the basis of such social problems as are usually encompassed by the term "the Woman Question." The position of woman, the equality or inequality of the sexes, woman's place in the sun, the double standard of morals, about all of which young dramatists and sociologists have perspired for so many æons, are at bottom biological problems, and not social or moral or economic problems at all. At times this is faintly recognized and even mildly mentioned, but in most discussions of the subject the biology and psychology of sex are treated as if they did not exist. But from the time when the morning stars sang together and until the period when the last representatives of animal life on the chilly remains of this planet are crawling along the shores of the still faintly warm rivulets at the equator, males will look at the phenomena of existence from one view-point and females from another. And that is one of the things I always tell my young candidates for ordination when they are sent to me for advice.

Instances are on every hand, but I will choose one of a totally impersonal nature from a recent volume of fiction — *The Painted Veil*, by W. Somerset Maugham. For purposes of experiment I have set a large number of women, fairly representative as to intelligence, to the perusal of a highly significant passage in this not otherwise notable book. I have directed their particular attention to a scene in which a woman has a very important conversation with a man.

The opening chapter of the novel depicts a bedchamber in the home of a British Government bacteriologist stationed in China. The time is early afternoon. His wife is entertaining her clandestine lover, who happens to be lieutenant-governor of the province. Their seance is interrupted by hearing someone trying to turn the knob of the door to the room. It is noted that the lieutenant-governor hastily attempts to put on his shoes. The intruder, however, goes away and the lovers convince themselves that it was merely a servant.

The next day the woman's husband discloses the fact that he himself was the intruder and that he thus assured himself of positive knowledge of the intrigue. The woman admits it frankly and says that if she is divorced, her lover will divorce his own wife and marry her. At this the husband is highly amused. His amusement provokes her to the most positive reiteration of faith in her lover. Whereupon the husband announces that he has been ordered to an inland city where cholera is raging; if he takes her with him, it means very probable death for both. If he goes alone, it means very probable death for him. He generously proposes that if her lover will make a statement in writing to the effect that when she becomes a widow, the lover will divorce his own wife and marry her, the husband will go to the cholera-infested city alone. If the lover refuses, she must either go with her husband into the danger zone, or submit to divorce under conditions amounting to disgrace. Certain of the loyalty of her lover, she goes to interview him. It is this interview to which I have directed the attention of my female friends.

The lover, of course, upon hearing the terms of the proposal, is thoroughly upset, fumbles round in a very inglorious manner, and finally flatly refuses. The woman sits before him aghast, with true astonishment. She has believed every one of his professions. He points out to her gravely and carefully how such a proceeding would jeopardize all his chances of advancement in the Civil Service, and that even on the chance that he did all this and married her, they would be ruined and penniless. She replies merely by saying: "But you said you loved me and would do anything for me." He acknowledges this, submits it was a justifiable overstatement under the circumstances, and hurries on to show that his wife is a perfectly innocent party and should not be required to suffer for their misdeeds. She replies merely by saying: "But you made me believe you loved me and promised to do anything for me." He turns from this to bring into her focus his children; he reminds her that she has no children to consider; his children require his care and also have a reasonable right to be protected from a legacy of disgrace. She merely repeats monotonously: "Why did you make me believe you really were mad about me?" So he has to reply shamefacedly that probably that is the kind of person he is. She then wants to know whether he is willing to allow her to go to her death. And he takes her in his arms and kisses her and says, in effect, that he is afraid he is willing to do just that.

Every woman to whom I have submitted this document has without exception applied exactly the same word to the lover. He is a "*cad.*" This, of course, is a female word, carrying with its

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use all the force and despotism of a shibboleth. The truth being that whether or not there is any word for him, the man is, under duress, exhibiting the quintessence of the male view-point. He is doing exactly what all wives, all safe women, all vested authority, have planned through all the ages that he should do.

It is because the women to whom I have submitted this problem fail so totally to grasp these elementary truths that I venture to elaborate the theme at such length. Let us get down to fundamentals. What is the female view-point? The female view-point is dependent upon an instinctive inner knowledge of the role the female plays in the process of reproduction. The female knows perfectly well that she must attract a male mate. She also knows that after she has attracted one, if she accepts him and submits to him, the legitimate result of the adventure for her will be pregnancy. During that period of pregnancy and even more so during labour and the period of the puerperium she knows that she will be helpless and relatively defenceless, that she will require guardianship, protection, and service. She will depend upon the male to furnish these. Therefore she will instinctively make perfectly sure of such things before she submits herself to him. In a state of nature among lower animals this is accomplished in many subtle ways. In a state of civilization the females from the earliest time have ranged Church, State, home, and Rotary on their side in order to compel its assurance. If some foolish one like the lady in my fable chooses to disregard these plain guide-posts, she has, if she comes to grief, only herself to blame. The male, in fact, has no such preoccupations as beset the female. He has no period of pregnancy in contemplation. He has no puerperium or feeding of the young to consider. He is scourged by another inexorable law of nature — the urge for reproduction, the will to live. He is expressly made to roam over the earth impregnating as many females as he possibly can. It is the deepest instinct in his heart, except the instinct for self-preservation. It is the deepest desire of nature, or, if you prefer the term, the deepest desire of God. It is simply silly to pretend that it is not, or to try to control it by moral admonitions. The only thing that can control him is the common sense of the female. The sense to lead him to the altar or the Justice Court, the sense to use the means her old mothers fashioned for her to bind him with hoops of steel. And he too uses wiles.

He will bow his neck to matrimony only if that is the only way out. He wonders all the rest of his life why he did it. He never submits tamely. He promises to love her for ever if she will accede to him. He lies, he coaxes, he fawns in order to accomplish his purpose. And after it is accomplished he is alertly ready for the next candidate, and to remind him of the means he used to accomplish it or to call him names for using them is as unworldly as to rebuke the flowers for blooming or the bees for visiting them.

And all these things, I think, I should tell to everyone's daughter. Except for the sly fact that she knows them already.

Of course, in a state of civilization certain modifications are imposed upon biologic laws. But the fundamentals remain. Love is a trick of nature — a trick to carry out her insatiable lust for reproduction. For Schopenhauer, you know, was right — the only God you can discern in nature is a "will to live."* I go into my garden — the shrubs, the flowers, and even more energetically the dandelions are reproducing as fast as ever they can. In my pool the little gold-fish are making new little gold-fish until the water swarms with them. Why? I haven't the slightest idea. At least I do not know the ultimate reason — the general scheme. Why they do it — the immediate impulse — is, I have no doubt, just as sweet and as irresistible to the gold-fish as to the boy and girl over the garden gate. Love is concocted of its unbearable ecstasy, and its poignant sweetness, because in no other way can the crafty old schemer, nature, carry out her purpose. The boy thinks it a specially dispensed miracle that he should be born in the same village with the one girl who is completely desirable. The poor dear does not know that he would have found one no matter where he was born. It is nature's way of getting her world populated. If either the boy or the girl realized the stifling responsibilities they were assuming, the last representative of the human race would ere long be sitting by the empty shores of the eternal ocean.

But they do not know, and society has wisely built up another trick, called marriage, because it found out that such things were necessary if nature's purposes were to be adequately fulfilled. The boy and girl enter this state two utterly unfamiliar elements. They enter it in a state of delirious ecstasy. They enter it because it seems to be the one way to carry out their most cherished and most selfish objects. Is it any wonder they so often find that instead of a paradise it is a prison? Is it any wonder that they find the two strange elements unassimilable? Is it any wonder that after a time they find themselves pulling to get asunder? They went in, as every human creature goes into everything, he to please himself, she to please herself. After marriage, in most instances, they each continue to try to please the one person they most wish to gratify — himself or herself. These two objects may conflict. And by that time there are the children to be considered. And the hoarse chuckle of Mother Nature and of Mother Church is heard in the wings. No, the wonder is that in so many instances it turns out well at all. For sometimes in spite of all the cynics and all the natural philosophers it does do that. Sometimes by some curious alchemy it becomes that very state which the marriage service so wistfully describes, "like unto the mystical union that is between Christ and His Church." How I do not know. Some union of purpose and of thought, some strange anabolism of human spirits, some mystical method by which two people can work out their separate destinies, yet work them out together.

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* I said in the presence of a great physicist once: "God is only the will to live." He replied: "My idea of the nature of God is that God is energy." I am inclined to think his definition is more comprehensive. But in the world of living creatures the will to live and to reproduce is at least half of nature.

Chapter II

THE MALE AND FEMALE ORGANS OF REPRODUCTION

More and more frequently as time leaves the tracery of respectability on my features, as the excesses of my youth tend to be forgotten and my figure grows magisterial, my friends are accustomed to send me their children at about the age of adolescence in order that I may explain to them what is called the secrets of life. I sit and look at these preternaturally solemn young persons, primed by their parents or guardians to expect some esoteric and recondite lore, and I wonder what I am going to say. They embarrass me dreadfully. Anything that I have to expound to them will seem so gross and mechanical beside that magical experience which one day will be theirs, when they learn that love is lovelier for its lust, and when their bodies become the most exquisite instruments to carry out the subtlest ecstasies of the spirit. For love is a mystery. And a mystery is at least this — it is an experience which happens to everyone, and yet to no two is it the same. So there is no way to tell them of a mystery. When their hour strikes, they will neither need nor heed any magisterial advice.

And so, quite frankly, I simply dodge the main issue. After all, that has been the wisdom of the ages — to dodge it, to allow everyone to find out about it for himself. If it were not so, why would not the parents themselves tell the secret? When I attempt to elaborate some of my reticences, the parents protest that unless the children learn it from me, they will learn it in the gutter. My reply to that is: "The gutter is a very good school." I am myself a matriculate from the gutter. I am inclined to believe that the pedagogy practised on me in the gutter was superior to any to which I was ever subsequently exposed. Here I find myself in the intellectual society of the "celebrated Mr. Veller o' the Bell Savage." "I took a good deal o' pains with his eddication, sir," Mr. Weller explained about his son Sam on that momentous occasion when he was first introduced to Mr. Pickwick. "Let him run in the streets when he was wery young and shift for his-self." They teach this particular subject very well in the gutter — with conviction and an inescapable clarity of detail, and with just sufficient of that gorgeous air of secrecy to invest it with the dubiousness of a speculation. In the gutter, best of all, they teach it as a joke. Which is just what it is. I keep explaining this carefully to all the ladies who object to my mildly smutty stories. It is the master joke of the universe. It is so magnificent a joke that the very stars rock with the echo of the laughter which it arouses. That is just why it has attracted all those masters of the art of words from the beginning of time — the great comedians, Aristophanes, and Rabelais, and Cervantes, and Shakspere and Sterne and James Branch Cabell. It is because it is a joke that it is holy. It is because it is a joke, not because it is holy, that it keeps us fascinated even after we have found it out.

When one turns from other methods than those of the gutter, what does one find? A psychoanalytical friend of mine, who leans strongly towards training children with all one's might and main, expounded to me one day *his* pedagoguery. He showed me the sweet little gardens where the male and female portions of plants were pointed out to children. He exhibited the darling little breeding-cages of dear little rabbits where the little ones carried out their own breeding experiments. Various other things. He told me of one little ten-year-old girl who had "developed the most beautiful and sacred attitude towards the problems of sex" and who had said, as an illustration, to her mother: "Oh! Mummy dear, I do wish you and fahthah would have another baby so that I might share your happiness all through the experience." I met this young lady, and I desire to record my matured opinion that she was the most insufferable, prematurely educated little prig I have ever been obliged to encounter. No! the knowledge of the secret of life is not gained in any such guarded fashion. It is gained with tears and sweat and by fiery swords; it is found in dark and sordid corners of the world, sometimes in beauty, sometimes in barrenness.

There are, however, a good many things that can properly be told the children — and those are the things I do tell them. The human male differs from the human female essentially in the organs of reproduction. The sex of the individual is determined

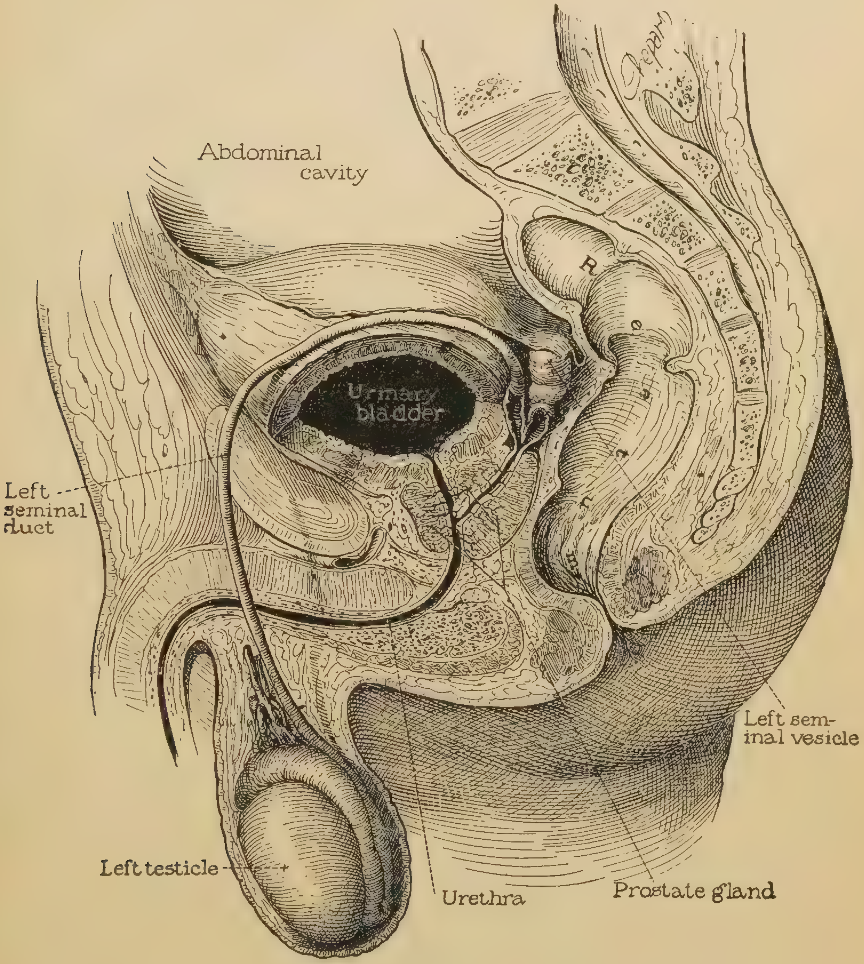

Abdominal cavity
Urinary bladder
Rectum
Left seminal duct
Left seminal vesicle
Left testicle
Urethra
Prostate gland

FIGURE 79

The male organs of reproduction.

at the time of impregnation by the kind of male element, or spermatozoon, which enters into the union, there being two kinds of male germ cells, one producing females, one males. (The details of this mechanism, which I shall not take space to recount, may be found in popular language in Curtis's *Science and Human*

Affairs, Appleton.) The male has two glands, the testes, constantly producing male elements of generation, spermatozoa, or sperms, which are small cells consisting of a head and an incessantly moving tail, which makes them automatically mobile. The testes are held in a sac of the skin called the scrotum. When matured, the sperms travel in the spermatic cord along the inguinal canal, or groin, and are deposited in the seminal vesicles, two small sacs just at the base of the bladder. Here they float in a fluid called semen, largely secreted by the prostate gland, a small gland also at the base of the bladder. The ducts from the seminal vesicles open into the urethra, a mucous-membrane-lined canal enclosed in the penis. At the time of ejaculation during the sexual act, the semen with the sperm is deposited in the female genital tract and the spermatozoa, on account of their endowment of motion, are able to enter the uterus and fertilize an ovum, provided one is present.

Aside from the tumours of the testes and venereal diseases, the most serious and frequent disease of the male generative organs is enlargement or hypertrophy of the prostate gland. In another chapter I spoke of the unfortunate embryological mistake which mixed up the generative with the excretory organs. The prostate is placed exactly at the neck of the bladder. Late in life, when most of the sexual functions are on the decline, it begins to enlarge. The cause of this is unknown. It seems to be one of those processes which occur in organs after the period of activity is over. In this respect it is not unlike the occurrence of fibroid tumours in the uterus of the woman. Whatever the cause, the symptoms are most distressing. The patient is often unable completely to empty his bladder. Sometimes the flow of urine is shut off and a hollow rubber tube, a catheter, must be inserted in the bladder to draw off the urine. Often the bladder becomes infected from the residual urine. Surgery is able to remedy the condition quite satisfactorily by removing the enlarged prostate.

The female organs of reproduction are all internal and consist of the vagina, or birth canal; the uterus, or womb, a hollow muscular organ lined by epithelium of a special kind called endometrium; and from each corner of the top of the uterus extend the two Fallopian tubes and below them are the two ovaries. The ovaries are not connected with the Fallopian tubes directly, but when an ovum develops, it comes to the surface of the ovary, and at maturity drops into the abdominal cavity, where it is immediately picked up by the fimbriated or tentacle-like ends of the tube and moves forward, propelled by small hairs on the cells of the lining of the Fallopian tubes until it reaches the uterus. Here it is either impregnated or cast off in the next menstrual period.

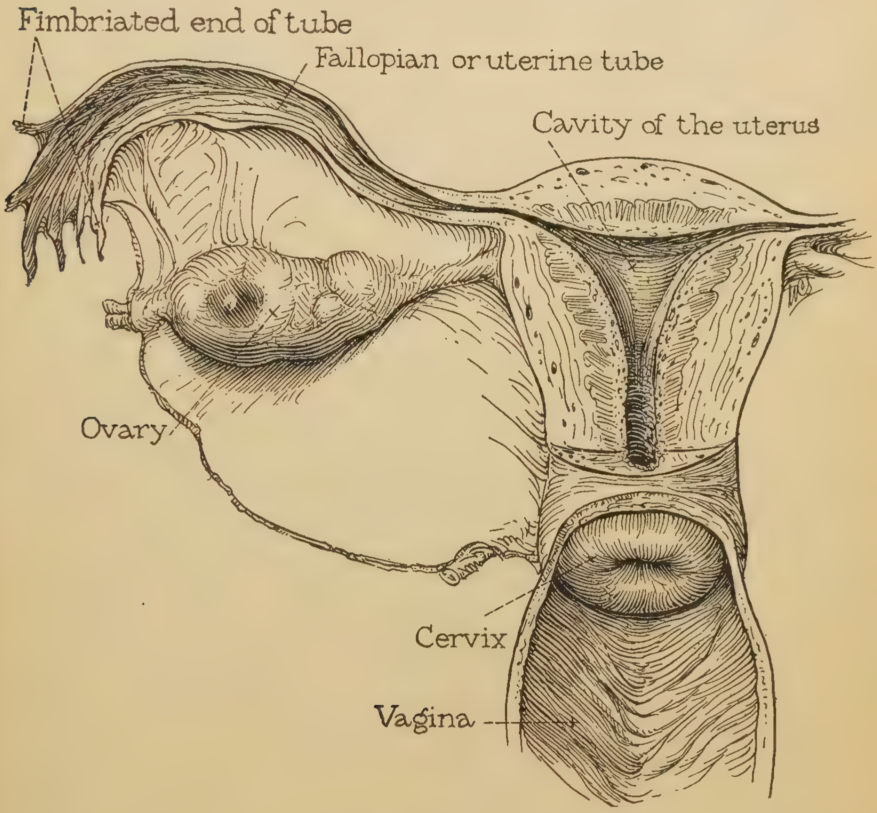

Fimbriated end of tube
Fallopian or uterine tube
Cavity of the uterus
Ovary
Cervix
Vagina

FIGURE 80

The female organs of reproduction.

Neither the male nor the female reproductive organs are fully matured at birth. They remain immature during the period of childhood, and mature rather suddenly at the age of about twelve to fourteen in girls and slightly later in boys.

Full maturity is ushered in somewhat dramatically in the female by the onset of the œstrual cycle or menstruation. Menstruation is the issuing of a mixture of blood and cellular debris, including an unfertilized ovum, from the uterus by way of the vagina. It occurs regularly under normal circumstances every twenty-eight days. Individual women vary somewhat in this respect, some having a menstrual cycle of twenty-one, some of thirty-five days. During pregnancy, when the ovum is fertilized, menstruation naturally ceases.

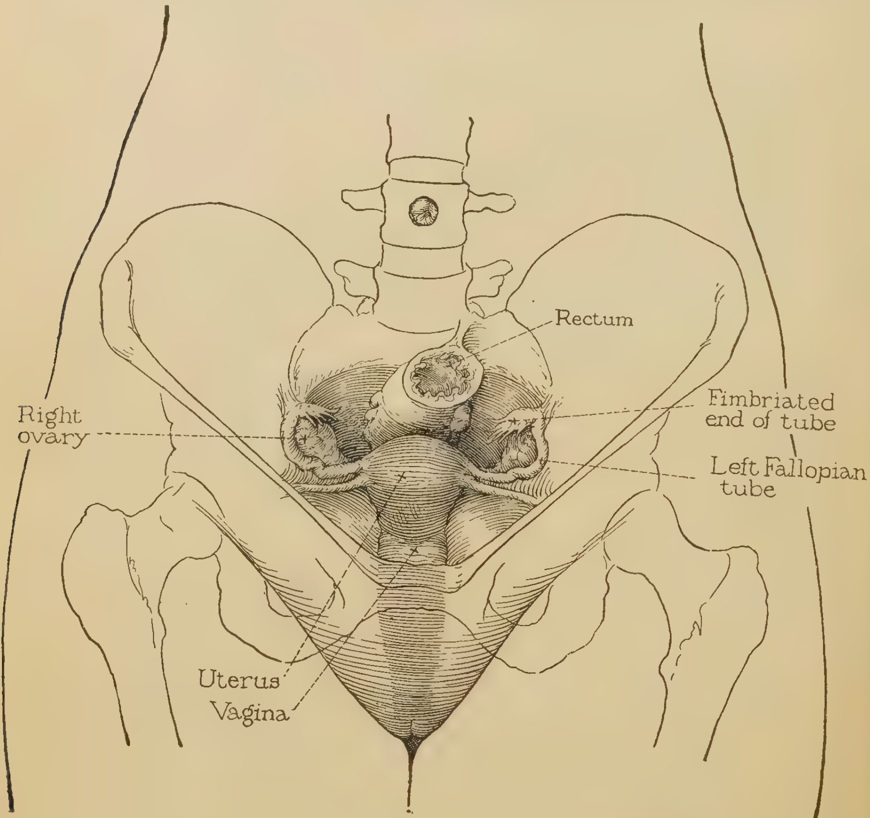
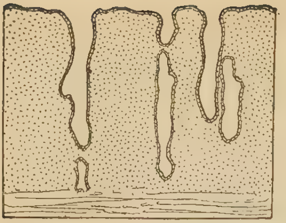


FIGURE 81

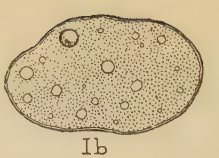
The female organs of reproduction shown in situ.

The mechanism of menstruation has been quite thoroughly worked out. The two ovaries at birth contain about 30,000 ova. No new ova are produced during the woman's lifetime. The ova are all in an immature state and are collected together below the surface of the ovary. One matures every twenty-eight days. In maturing it works its way up to the surface of the ovary, surrounded by a number of epithelial cells and by a liquid medium. Just before it is fully ripened, it appears under the surface membrane of the ovary as a small blister. This is called the Graafian follicle. The fluid contained in the follicle is very important and is called the liquor folliculi. During the period of maturation of the ovum the lining membrane of the uterus has also been undergoing changes. The cells multiply and the whole endometrium becomes thickened and congested. When the Graafian follicle ruptures, the ovum enters the Fallopian tube and makes its way to the uterus, the lining membrane of which has grown thick and ready to receive it. Upon this thickened endometrium it rests a few days. If impregnation by the male sperms occurs at this time, the ovum begins to develop and the state of pregnancy is initiated. If impregnation does not occur, menstruation occurs, and the unfertilized ovum is cast off, a new ovum begins to develop in the ovary, and the whole cycle starts anew.

A most interesting recent piece of research in this particular field is the demonstration by Dr. Edgar Allen of the University of Missouri of the chemical agent or hormone which after absorption into the blood causes menstruation. This ovarian hormone controlling menstruation appears to be held in the liquor of the Graafian follicle. By injections of it Dr. Allen has been able to produce menses in monkeys at any time, irrespective of the period of the menstrual cycle. Dr. Allen was compelled to use monkeys as his experimental animals, as they are the only ones which have a menstrual cycle at all resembling the human cycle. In other animals the œstrual cycle — designated by the terms "heat," "rut," etc. — is of an entirely different character, consisting of marked changes in the external genitalia, occurring at or near the time of ovulation, accompanied by a strong instinct for mating. Experiments made by Dr. Allen on women with various diseases indicate that the use of the ovarian follicular hormone in such conditions as the artificial menopause due to surgical removal of the ovaries, the natural menopause, amenorrhœa or lack of menstruation, scanty menstruation, and immaturity is very successful. We have thus only recently acquired the means to utilize ovarian substance on the same scientific basis as we use



Ia

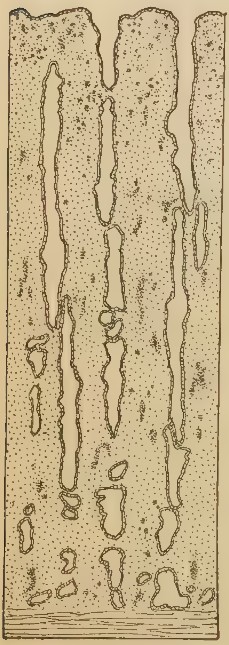


Ib

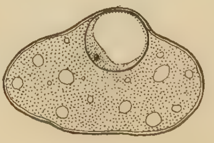
Menstruation: The stage of rest. One to four days after menstruation.

a. Thin uterine mucosa.

b. Graafian follicle maturing in the ovary.



IIa



IIb

Stage of active secretion of maturing ovum.

a. Thickened uterine mucosa preparing for the reception of the ovum.

b. Graafian follicle matured and ready to discharge the ovum.

After the ovum reaches the womb, the subsequent events depend upon whether it is fertilized by the male sperm or not.

If fertilization does not occur, MENSTRUATION, as shown to the left, begins.

IIIa — The uterine mucosa is cast off and the ovum with it, in the menstrual discharge.

IIIb — In the ovary the remains of the Graafian follicle shrivel up and disappear. If fertilization occurs, PREGNANCY, as shown in the right hand diagram, begins.

IVa — Uterus with thickened mucosa, the fertilized ovum beginning to develop into the child.

IVb — Ovary with corpus luteum of pregnancy. In the ovary there is formed the corpus luteum of pregnancy, from the Graafian follicle after release of the ovum. This persists throughout pregnancy, giving out an internal secretion, which influences the formation of the placenta, and the hypertrophy of the uterine mucosa.

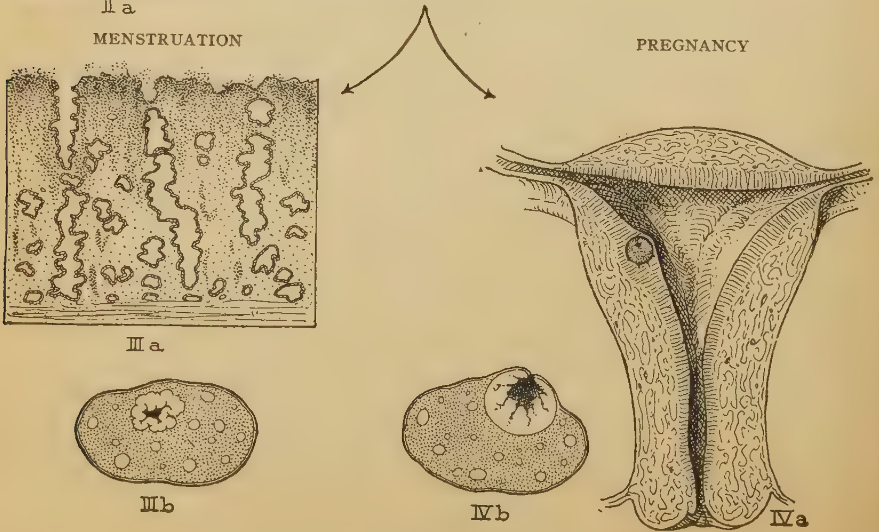


Figure 82

The mechanism of menstruation and ovulation.

extracts of the other ductless glands — insulin, thyroxin, epinephrin, and pituitrin.

The active period of female sexual life lasts about thirty to thirty-five years. At somewhere about the age of forty-five to fifty (though there are, of course, wide variations in this rule) the menses begin to be irregular and scanty and finally cease. This period is called the menopause. At this time the ovaries atrophy and the uterus becomes smaller. Various accompanying symptoms are extremely annoying. Changes in the vascular control, possibly on account of concomitant changes in the adrenal glands, cause heat flushes and hot flashes over the body. There is a strong tendency to the deposit of fat, particularly round the buttocks. Mental instability and depression are almost invariable. It is truly a time of storm and stress. The woman feels her essential femininity departing from her. If she is married, she has the consciousness that while her mate is still vigorous, she is no longer capable of being entirely his mate. As Dr. Reed well says: "It is evolution for him, it is revolution for her." All the ductless glands recede in activity at this time and the thyroid may become totally atrophied, leading to the condition called myxœdema. She needs careful watching and tender care during this period. Sometimes she is totally shipwrecked, but this is rare. Usually she may be assured that the storm will pass and the calm peace of perhaps the happiest period of life will descend upon her.

Disturbances of menstruation may be of three kinds. Amenorrhœa is suppression or cessation of menses. Its most usual cause is the onset of pregnancy. Psychic states may produce it. Wasting diseases such as tuberculosis, diabetes, and fevers suppress menstruation. Menorrhagia is an increased amount of menstruation at the normal time; the increase may be in amount or in the length of the period or both. It is always a sign of disturbance of some sort — infection of the tubes, fibroid tumours of the uterus, tubal pregnancy, and cancer of the uterus are the most frequent causes. Metrorrhagia is menstruation or an increase of blood occurring between the regular menstrual cycle — its causes are in general the same as for menorrhagia. Any of these may, of course, be the sign of the onset of the menopause, but always their appearance demands a careful examination.

The diseases of the female reproductive organs are very frequent, owing to the many stresses the parts ordinarily undergo. They are, in the first place, subject to the venereal diseases to which they are exposed during the sexual act, from an infected male — particularly gonorrhœa. Secondly the trauma and infections of childbirth leave a train of disablements in their wake. And lastly these organs are peculiarly adapted to a general pathologic rule that an organ which has had an active function and then atrophies is particularly liable to degenerative disease, especially tumour growth. The first two will be considered briefly in succeeding chapters.

The diseases, aside from venereal disease and those caused by childbirth, which particularly affect the female genital tract are the tumours of the uterus, and cysts and tumours of the ovaries. The commonest tumour of the uterus is the tumour made up of fibrous tissue called fibroma or fibroid. It may contain glandular tissue when it is an adeno-fibroma or strictly an adeno-myoma. For a discussion of the pathology of these tumours turn to the chapter on neoplastic diseases. Here we shall recount the symptoms and treatment for household guidance. Though these growths may occur at any age, they are more likely to appear at the time of the menopause than any other. They may be as large as a child's head or as small as a hickory nut. If they are large and placed on the outside of the uterus, the important symptom will be the growth of a hard tumour in the abdomen. They are often mistaken for a pregnancy. If they are small and placed close under the uterine mucosa, the prominent symptom will be bleeding. Both tumour and bleeding may occur. On the contrary they may be small and centrally placed where they will be completely silent. The only effective method of treatment is surgical removal. Exposure to the X-ray will often stop the bleeding, and cause some diminution in the tumour.

Cancer of the uterus occurs at two places — in the cervix, where it is very serious, and in the fundus, where it is nearly always completely removable. The cervical cancers metastasize more readily than the fundic ones. Both kinds are signalized to the patient by the presence of bleeding. Any irregular bleeding resembling menstrual bleeding but at the wrong time should always be investigated. If the physician waits until the signs of cancer — emaciation, pallor, and weakness — supervene, it may be dangerous. Operation and exposure to the X-ray and radium are the only methods of treatment yet approved.

The tumours of the ovary mostly take the form of cysts. A cyst is a collection of liquid held or surrounded by a membrane. Cysts of the ovary may become enormous, sometimes after removal weighing more and being larger than the individual from whom they were removed. If most of them are completely removed, they do not return.

Ovarian cysts have an especial interest for us because it was by them that all abdominal surgery was first inaugurated. The story is almost incredibly romantic.

Dr. Ephraim McDowell, a country practitioner in Danville, Kentucky, which was then on the very border of the wilderness, first successfully removed an ovarian cyst from Mrs. Jane Crawford, the wife of a pioneer. The date was 1809. No anæsthetic was used and no asepsis even attempted. The words of Dr. Lewis A. Sayre in a speech on the occasion of the dedication of the McDowell Memorial at Danville were not the words of fulsome oratory when he said that "the success of the operation and the success of the establishment of abdominal surgery were due as much to the courage of the patient as to the daring of the surgeon." Remember that up to that time and long afterward the opening of one of the serous cavities of the body — the abdomen with its peritoneum, the chest with its pleura, even one of the joints with their serous surfaces — was invariably fatal to the patient. Larrey, the surgeon of the Napoleonic armies, with his thousands of cases, had only two of amputation at the hip-joint which recovered. In the works of Cheselden, who cut for the stone in the seventeenth and eighteenth centuries, is the record of a case which he regards as absolutely unique, of a woman who had a strangulation of the bowel, which he cut into by opening the peritoneum and the woman lived. He puts it forward in so many words as a case which proves that every patient whose abdomen is opened does not die. Before this time surgeons were able to remove kidney and bladder stones because in so doing they avoided the peritoneum. They made amputations between joints. They removed external tumours (recall *Rab and His Friends*). But they let the serous cavities severely alone.

Then all of a sudden, in the wildest part of the civilized world, a country practitioner does what no professor of surgery in Europe dares to do; he opens the abdomen, removes an ovarian cyst weighing twenty-one and one half pounds, closes the incision with interrupted sutures, and five days later, according to his notes, which reached even the clinics of China, the patient is up making her bed, and twenty-five days after the operation returns in a wagon to her own home. How Dr. McDowell avoided infection no one knows. Probably he was naturally clean, and did not handle pus, and what mild infection there was quickly cleared up. At any rate McDowell is one of the few Americans who have made permanent and invaluable contributions to medical science and practice. His biographer calls him "the father of abdominal surgery." The only other American physicians worthy to be placed with him are Beaumont, who first put the physiology of digestion on a sound basis, and the co-discoverers of the anæsthetic properties of ether, Morton and Long.

Since it occupies so large a place in practice to-day and since it made a start and is still supreme in the field of the female generative organs, it may be proper to discuss here the development and present accomplishments of surgery. McDowell's operation by no means put abdominal surgery on a firm basis. McDowell's accomplishment was to show that abdominal surgery was a possibility. He ended what has been dubbed "the stone age of surgery," so called on account of the predominance of "cutting for the stone." He was, previous to this time, a surgeon of wide repute in his large but thinly populated district. He cut for the stone thirty-two times up to 1828, one of his patients being James K. Polk, on whom he operated in 1812. Yet, in spite of his wide reputation and the confidence reposed in him, there is a tradition that a mob gathered about his house on the morning he was to operate on Mrs. Crawford and threatened to prevent the operation by force. Although McDowell successfully performed ovariotomy twice afterwards, operations of this kind were by no means generally attended with good results and it cannot be said that the principles of the surgical art were established. The two great bugbears were pain, amounting to torture, and infection.

Anæsthesia, which conquered pain, was established for surgical operations as a part of practice by W. T. G. Morton, a Boston dentist, in 1846. Almost from the first announcement the priority was contested by Dr. Crawford Long, who undoubtedly rendered a fee bill to a certain Mr. Venable for a small operation under ether in 1842. The controversy need not detain us. Morton's work was certainly independent and established ether as the adjunct of surgery. October 16, 1846, was a great day for mankind when, in the domed surgical amphitheatre of the Massachusetts General Hospital, John Warren, Professor of Surgery at Harvard, removed a tumour on the left side of the neck, and allowed the young dentist to try to put his patient to sleep with ether.

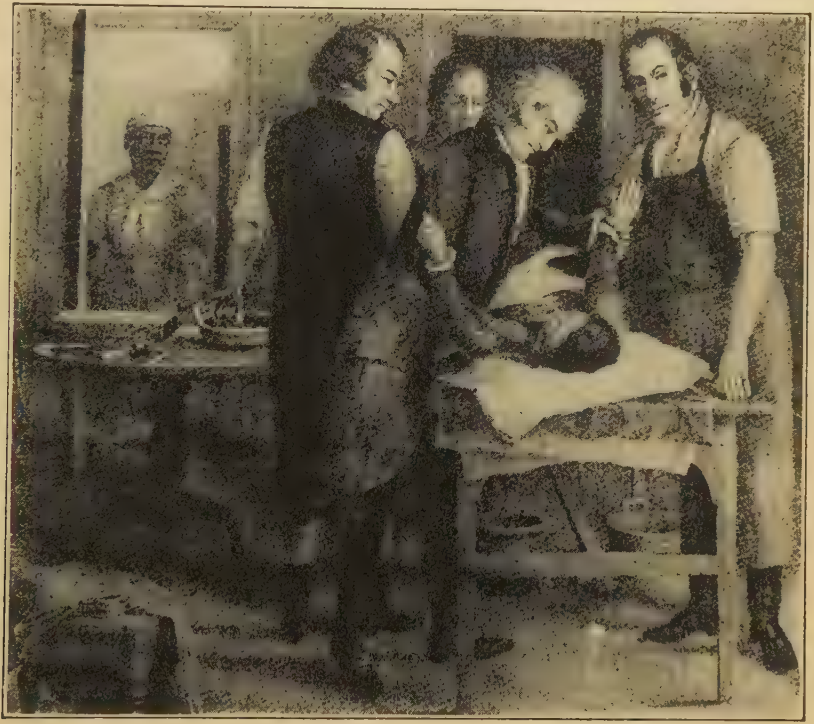


FIGURE 83

The first successful abdominal operation. The first ovariotomy performed by Dr. Ephraim McDowell at Danville, Kentucky in 1809. No anæsthetic and no antisepsis were used. The photograph is from an old painting made after the event. Dr. McDowell is represented at the extreme right.

The usually recited story is that Morton was late, delayed because he was waiting for a new inhaler to be completed; that Dr. Warren sarcastically remarked: "As Dr. Morton has not arrived, I presume he is otherwise engaged" — implying that

Morton was staying away because he was an impostor; that just then Morton entered the surgical amphitheatre, and as he did so, Warren said: "Well, sir, your patient is ready" — that Morton administered the anæsthetic and, when the patient was asleep, replied: "Dr. Warren, *your* patient is ready" — and the operation proceeded.

There is extant the account of an eyewitness, Dr. G. M. Angell of Atlanta, which does not tally with this version. Dr. Angell considered that he was watching the first surgical operation performed under ether. He was an old man when he wrote his memoirs and it is almost certain that it was not the first, probably the third. The operation he saw was a leg amputation. His account, however, is so dramatic and vivid that I should like to quote it in part and paraphrase the rest.

W. T. G. Morton was not an obscure member of the dental profession when he made the claim to have discovered a surgical anæsthetic. He was one of the best-known dentists in Boston. He was a graduate of the Harvard Dental School and in the "Ether Room" of the Massachusetts General Hospital are preserved, along with many other historical mementoes, his cards for lectures. After several years of successful dental practice during which he and another dentist, Horace Wells, tried laughing gas for dental anæsthesia, Morton fell in with Dr. Charles Jackson, who suggested the use of ether to him. Morton had tried this agent out successfully in dental operations.

The scene is the Massachusetts General Hospital in Boston, one of the oldest of its kind in America, established in 1811. The surgical amphitheatre, still preserved intact with the same tables and chairs, is at the top of the central part of the old wing of the building. The surgeon is Dr. John Warren, president of the faculty and professor of surgery at Harvard. His father, Dr. John Warren, had established the Harvard medical school and founded the Massachusetts General Hospital. A relative, Dr. Joseph Warren, had been killed at Bunker Hill.

Some time during the middle of the lecture term in the fall of 1846 a rumour was circulated among the medical students in the city that an agent which would do away with the pain of a surgical operation, however severe, had been discovered. At length it was announced that Dr. Warren would make use of this agent while performing an amputation of a leg. This statement reached the newspapers of the city and excited much discussion among the surgeons and physicians of Boston. It must be remembered that many agents had already been tried. Hickman and Wells independently had used nitrous oxide; it had worked satisfactorily for dental extractions, but had been found impractical by the methods of the time for the larger operations. Hypnotism had been tried with slight success. Animal magnetism, a fad of the day, had been a total and disgraceful failure.

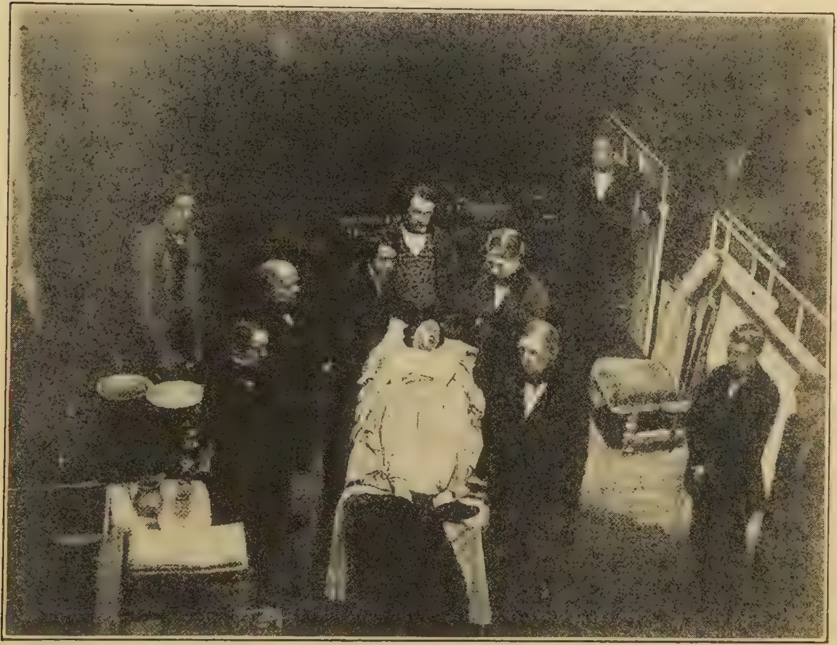


FIGURE 84

One of the first operations under ether. From a daguerreotype. Dr. John Warren stands far down in front at the left side of the table. W. T. G. Morton stands at the patient's head. The room is the ether room of the Massachusetts General Hospital in Boston, and an attempt has evidently been made to reconstruct the scene of the first administration of ether, publicly done for a major surgical operation

"On the morning of the day set for the operation," states Dr. Angell, "I went as usual to the hospital, but much earlier, as I anticipated from the great reputation of Dr. Warren and the importance attached to the experiment that there would be a large attendance at the clinic.

"When I arrived, a very large crowd had already assembled in front of the hospital, reaching out to the side-walk and street, but the door was kept closed until the usual hour of opening arrived. I passed in by a private door with a student; we went directly to the operating-room and chose our seats. This room was a vast amphitheatre with terraced seats rising in a circle on three sides of the room almost to the ceiling. In front of these seats and separated from them by a low railing was the operating-stage, a door leading out from it into the wards of the hospital.

"My companion and myself took our seats close to the railing and directly opposite to where the operating-table stood, and impatiently awaited events. Meantime the crowd outside increased to such an extent that when the hour arrived and the doors were opened, the great hall was filled to overflowing with the rushing host, which filled the seats and aisles to their utmost capacity.

"In the amphitheatre were Dr. John Mason Warren, son of Dr. Warren, Dr. Bigelow, son of the professor of theory and practice in Harvard, and Dr. Parkman, who had just entered on their professional careers, and all of them, in subsequent years, became celebrated as authors and practitioners.

"Presently Dr. Warren, Sr., came in, and soon after a young man having in his hands a glass globe, perhaps eight inches in diameter, with a mouthpiece attached and a hole in the top, stopped with a cork, containing a clear liquid; we did not know what it was.

"I was not personally acquainted with this gentleman, but it was whispered around among the seats that this was Morton, the reputed discoverer of the agent which was to be experimented with.

"Very soon the ward attendants brought in the patient who was to be operated on, a young woman about twenty-four or twenty-five years of age, and laid her on the table. The three young attendants arranged themselves in line on the opposite side of Dr. Warren, Sr. Morton leaned against the railing a few feet from where we sat, holding the globe in his hands."

Dr. Warren began to discuss the clinical features of the case. He stated that the patient had necrosis of the knee-joint. He commented on the nature of this disease quite fully. He described the palliative measures which had been employed in this particular patient, all of which had proved abortive. Amputation was, therefore, necessary. This had been explained to the patient and she, convinced of the necessity for it, had consented.

As he spoke, a profound, an unaccustomed silence fell upon his audience. From the bottom row to the top, not a whisper of comment, not the scratch of a pencil taking notes, was to be heard. In all that he had said so far, however, "there was no deviation from the usual custom before an operation: he was the same quiet, dignified old gentleman as when talking to a few medical students sitting on the benches."

Slowly now Dr. Warren turned a little more to face his audience, and his voice took on a graver tone.

"I have been," he said, "forty years a surgeon in Boston. From time to time, during that period, persons have come to me and said that they had an agent which would do away with the pain of a surgical operation. On account of the great blessing it would be to the human race if such an agent could be discovered, I have heard what they had to say.

"If I thought there was no danger to be apprehended from the remedy, and if they were persons whose characters and standing seemed to entitle their opinions to respect, I have made the experiment desired. I have tried galvanism, magnetism, and hypnotism" — and as he said these last words the witness avers that a curl of his lip indicated his opinion of them. "But," he continued, "in every instance when the knife was applied to live tissue there was pain. And now we have a gentleman here who tells us that he has a liquid preparation by the inhalation of which the pain will be entirely done away with in the operation. He has furnished abundant evidence of his having administered it frequently in minor surgical operations, and that no pain was felt and no injury occurred to the patient.

"Mr. Morton," he continued, addressing the young man who stood leaning on the rail of the amphitheatre, "will you come forward and administer your agent to this patient?"

Morton came up to the table and put the mouthpiece of the inhaler to the mouth of the patient. He gave her a few whispered directions and took the cork from the hole in the top of the globe. The patient's eyes were closed like those of one in sleep and soon the chest rose and fell as in deep, natural sleep.

The intense silence which had fallen over the audience was broken by Morton. He took the mouthpiece from the patient's mouth and said in a loud voice to Dr. Warren: "She is ready for the operation, sir." Dr. Warren searched for a pin in the lapel of his coat. "You think she will not feel any pain now, do you?" he asked. He took up the arm of the patient and forced the pin into the skin, at the same time looking at her face. He repeated this two or three times; the muscles of her face did not indicate that she felt any sensation. Dr. Warren turned quickly, picked up a catling, and made a rapid incision through the skin and muscles at the lower third of the thigh. At this point he stopped and looked earnestly at his patient; not a muscle in her face twitched. He finished the division of the muscles, sawed off the bone, and put the leg under the table in front of him. He stepped aside, crossed his arms behind him, and said: "John, tie those arteries."

While his assistants were completing the operation, the old gentleman walked back and forth across the stage, and as he passed her, he would look down into the patient's face. Just as the operation was completed, she turned her head a little to one side and gave a groan. Dr. Warren took hold of her sleeve and called her name. She looked up at him in a dazed manner and said: "Sir." "I guess you've been asleep, Jane," he said. "I think I have, sir," she replied. "Well, we brought you here for the purpose of performing the operation on your limb. Are you ready for the operation?" "Yes, sir," she said, "I am ready." He reached out, picked up the amputated leg, showed it to her, and said: "It is all done."

The scene which followed was one of pandemonium. Men were beside themselves with joy. They clapped their hands, stamped and yelled. During this demonstration the patient was carried into the ward and put to bed. Dr. Warren continued to walk to and fro on the stage. Finally turning to the audience, he said in a voice shaking with emotion: "Gentlemen, this is no humbug."

Infection, the most dreaded of all the dangers of the surgeon, heard its death-knell in the work of Pasteur. Infection was caused by minute germs in the air, on the hands and the instruments of the surgeon. Koch showed the cause of wound infection — the staphylococcus and the streptococcus. It remained for the genius of the Scotch surgeon, Joseph Lister, working in the old Edinburgh Infirmary, to read these announcements and realize their significance for his art. If one boiled one's instruments, the germs would die. If one sterilized one's hands and the patient's skin with carbolic acid, one would be safe. If the air of the operating-room were sprayed with carbolic-acid vapour, the germs would be killed. It was tried and it worked. The human body could be cut anywhere and no, or little, infection result. For all the horrible and hopeless forms of disease there was at last hope — the monstrous tumours, the twisted limbs, the blind eyes, the pockets of pus, the stones (not only of the kidney and bladder, but of the gall-bladder), the ruptures, the bags of water — all have disappeared under that magical touch. Improvements in the method came. The air disinfection with the carbolic spray, which filled operating-rooms for a while with such a vapour that the manipulations of the surgeon could not be seen, was found unnecessary and done away with. It was contact infection from hands, instruments, gauze, and towels that was to blame. Carbolic acid, with its irritating effect on the skin, was replaced by

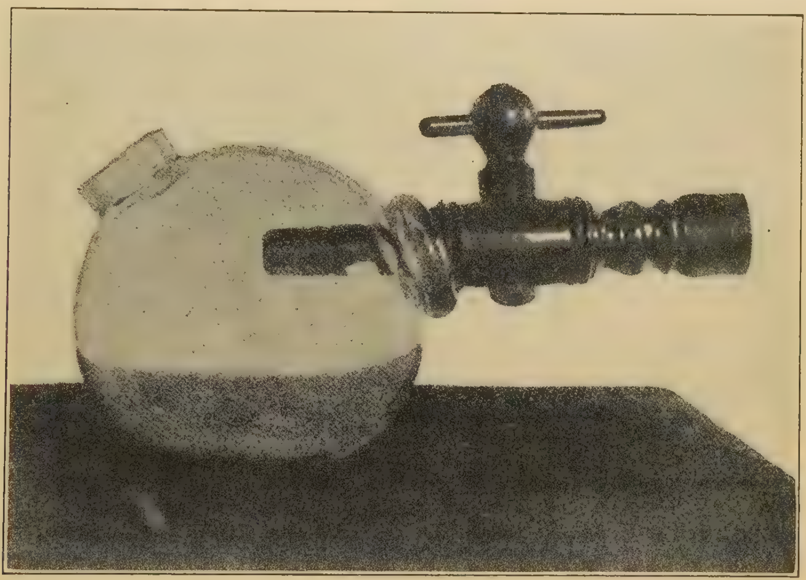


FIGURE 85

The original ether inhaler designed and used by W. T. G. Morton.

equally effective but non-irritating antiseptics — alcohol, iodine, and bichloride of mercury. To-day mere cleanliness, that found in soap and water, is found to be almost entirely sufficient.

The amount of happiness which has resulted from all this is beyond calculation. The knowledge of it has gone everywhere and filled every living human heart with hope. It is almost impossible to project oneself backward to the view-point of a person living with his human body in the days before antiseptic surgery and anæsthetics. People, at least some people, naturally do not like operations and try to avoid them, but suppose there were no operations to be avoided. It would be an unthinkable world.

CHAPTER III

PREGNANCY AND LABOUR

As soon as impregnation of the ovum occurs and the development of a new individual within the uterus begins, profound changes are initiated all over the female body. To the alert neighbours these are not evident until six months later, and attention is then centred upon the increase in the size of the uterus. But even before the husband finds the little sock in the sewing-basket, adjustments have occurred in nearly every organ of the mother's body. She has now to digest, absorb, nourish, and excrete for two. The heart, therefore, pumps a little harder. The liver and kidneys bear an extra burden of work. Metabolism is carried on at a higher level and the thyroid gland enlarges slightly. The ovaries stop ovulation, so there will be no ovarian follicular hormone absorbed and no menstruation. The breasts begin to enlarge and to prepare to secrete milk.

The most conspicuous change is, of course, the increase in the size of the uterus. This is a very remarkable phenomenon. During a period of approximately two hundred and eighty days it increases in size about four hundred times. The number, size, and strength of each individual fibre are greatly increased — each muscle-fibre increases to about eleven inches long, and is five times thicker than normal. At the end of the period, after delivery is effected, it recedes in a comparatively few days, all the extra substance being absorbed in some way so that normal size is again attained. Through what chemical processes, through the action of what hormones, all this occurs is totally unknown.

In the mean time the development of the fœtus, or child, is proceeding. As soon as the ovum and the sperm unite, they form a single cell; each of them has one half the normal number of chromosomes present in all the body-cells of the individual. When union has been accomplished, the cell immediately begins to divide very rapidly until a round mass of cells, the morula, results. A cavity makes its appearance in the interior of the morula, and from one side of this mass of cells, called the germinal area, the new individual begins to be formed. The complex series of changes in development is studied by the science of embryology. It is, strictly speaking, part of the science of anatomy. Anatomy has learned from this study a great deal of the way in which individual organs have been laid down in the embryo. Many puzzling things about the human body are explained in the light of development. For instance the nerve which innervates the muscles of voice on the left side of the larynx originates high up in the neck and travels clear down into the chest, hooks round the arch of the large blood-vessel from the heart, the aorta, and then returns to the larynx in the throat. Why? It seems such a waste of material. Study of the developing embryo supplies the answer. Because the embryo at one stage is a fish. It has gills. From the gills the lungs develop. And the vessels which ran along the gills move down with the lung anlage (the name given to a primitive organ) into the chest. Doing so, they drag the recurrent laryngeal nerve down with them. It is one of the ludicrous mistakes in the body.

Into all these matters, which are not easy to explain in simple terms, it is not necessary for us to inquire. It is sufficient to say that the germinative area splits into three layers of cells, the *epiblast*, the *mesoblast*, and the *endoblast*. From the epiblast are derived the skin and its appendages, hair, nails, mammary glands, etc., the nervous system, the mouth and teeth, and the lower part of the rectum. From the mesoblast are derived the muscles, the bones, and the connective tissue; the kidneys, the organs of generation, the blood-vessels, blood and lymphatics. From the endoblast are derived the digestive tract and its glandular outgrowths, the liver, pancreas, etc., the lungs and the bladder. An interesting speculation is to suppose that each of these germ layers, and hence the organs which develop from them, has a definite and individual chemical reaction and method of response, and to catalogue disease processes on the basis of their affinity for epiblast, mesoblast, or endoblast tissues. Certain forms of syphilis, for instance, seem to attack especially the epiblast — the skin lesions, the hair falling out, the mouth eruption, and the nervous manifestations. Tuberculosis is mesoblastic and endoblastic. Cancer is epiblastic. The analogy, however, can be pushed too far.

A necessary adjunct for the growing fœtus is to provide it, naturally an air-breathing organism, with oxygen during the period of intra-uterine life, when it is excluded from air. This is accomplished by the development of the umbilical cord and the placenta. Both of these structures are developed from the ectoderm of the embryo. When they are completed, the fœtus rests inside a closed membrane which completely fills the inside of the uterus. It contains a heavy liquid, the amniotic fluid, so that before birth the baby leads an aquatic existence. The blood-vessels and heart of the fœtus are different from the adult's in some respects, before birth, because from the centre of its abdomen a cord of blood-vessels goes to a large sponge-like mass of tissue, the

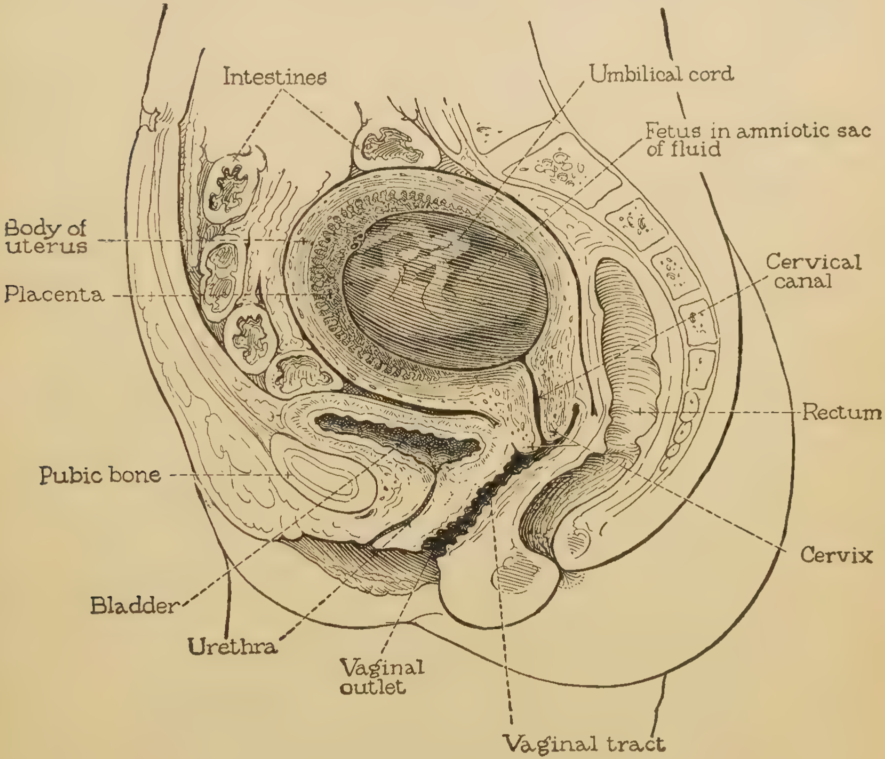

Intestines
Umbilical cord
Fetus in amniotic sac of fluid
Body of uterus
Placenta
Cervical canal
Rectum
Pubic bone
Cervix
Bladder
Urethra
Vaginal outlet
Vaginal tract

FIGURE 86

Pregnancy in an early stage. Note that the fœtus is enclosed in a liquid medium, the amniotic fluid, which is held inside the uterus. Note the umbilical cord, which is composed of blood-vessels connecting the child to the mother by way of the placenta. The mother's blood brings oxygen and food to the child and carries away the child's waste products.

placenta. The placenta lies outside the amnion and is embedded in the mother's uterus. Finger-like processes go down to a nest of blood-vessels in the uterus, each of these finger-like processes or villi bearing a small vessel in the centre. In this way an exchange of gases between the mother's blood and the child's blood occurs. The mother's blood gives up oxygen, which is carried to the child's body and serves in lieu of breathing. The mother's blood takes up carbon dioxide and other waste products from the child's blood and excretes them by the kidneys and lungs.

There are times when these extra burdens become too much for the maternal organism. This is perhaps an unscientific way to describe the toxæmias, or poisonings, of pregnancy, because we are in the dark as to their cause, but at least it is as good as any explanation known. These poisonings are of various kinds. One is an increase in the vomiting which is normal, almost inevitable, in the early stages of pregnancy. It becomes so severe that vomiting goes on day and night, resulting in great emaciation and at last danger to life (pernicious vomiting of pregnancy). Many of the cases can be successfully treated; for some the prostration becomes so great that the pregnancy must be terminated. When this is done in time, the mother immediately recovers. The most severe of the toxæmias of pregnancy is eclampsia. The cause is not known. The cells of the kidneys are degenerated and widespread destruction of liver-cells is seen. ECLAMPSIA has its onset usually during the last three months of pregnancy. The symptoms are headache, gradual loss of acuity of vision, albumin in the urine, increased blood-pressure, bloating and œdema of the face. The danger signs are convulsions resembling epileptic seizures. It is very serious. Treatment directed towards elimination is the first essential — sweating, catharsis, etc. Termination of the pregnancy must usually be performed to save the mother. Early recognition of the first symptoms on the part of the expectant mother is most important. Headache, visual disturbance, such as spots before the eyes, slight blindness while reading or sewing, nausea and vomiting recurring later (not the early normal vomiting of pregnancy), dropsy of any extent except in the feet and legs, which is natural, should immediately be investigated.

Pregnancy does not always occur inside the uterus. EXTRA-UTERINE PREGNANCIES, especially tubal pregnancies, are far from uncommon. In this condition the ovum does not, for some reason, manage to get to the uterus. It remains in the Fallopian tube and there is found and fertilized by the spermatozoon. Pregnancy cannot, of course, proceed here without rupture of the tube. Fortunately the symptoms are quite well known, and surgery can save all such unfortunate cases. The history is that the woman misses a menstrual period and thinks she is pregnant. The breasts enlarge somewhat; all the subjective signs of pregnancy are present. Then a sudden discharge of blood occurs from the vagina, like a menstruation. There will always be shreds of tissue in this discharge. Later severe cramps in the abdomen with renewed bleeding occur. A competent physician can make the diagnosis at any stage, and an abdominal operation, with removal of the affected tube, is always safe.

LABOUR, the emptying of the uterus at the end of pregnancy, consists essentially in a series of muscular contractions of the uterus. These contractions cause cramps and are the pains of labour. Labour is usually divided into three stages. During the first stage the uterine contractions cause complete dilatation and relaxation of the uterine birth canal, the cervix. During the second stage the child is expelled from the uterus, moves down through the vagina past the perineum, the muscular base of the pelvis, and is completely extruded into the outer world. During the third stage the placenta or afterbirth is detached from the uterus and is pushed out by uterine contractions after the birth of the child.

The mechanism used during the first stage of labour is hydraulic compression. The amniotic sac, containing the amniotic fluid, is like a toy balloon filled with liquid. When the muscle of the uterus contracts, the balloon and its fluid are naturally the first to be pressed out of shape. The round edge of the amniotic sac with its heavy content of liquid bulges against the inside of the cervix, and begins to open the ring gradually but evenly on all sides. The uterine contractions, or labour pains, are mild at first, and quite an interval apart, but they gradually become longer and harder and closer together. It is a great advantage to preserve the amniotic sac intact during this stage. The hydraulic pressure it exerts is the best way to open the cervical canal. When it ruptures early, a dry labour, which is usually a long and difficult one, results. The sac usually ruptures spontaneously at the end of the first stage — "the waters break," in the words of the old wives and midwives. Sometimes the child is born with the amniotic sac intact. It is called being born with a caul and is a sign of good fortune. David Copperfield, you will find if you renew his acquaintance, was born with a caul. You need go no farther than the first page. If you should venture to the second page, you will, I guarantee, be amused.

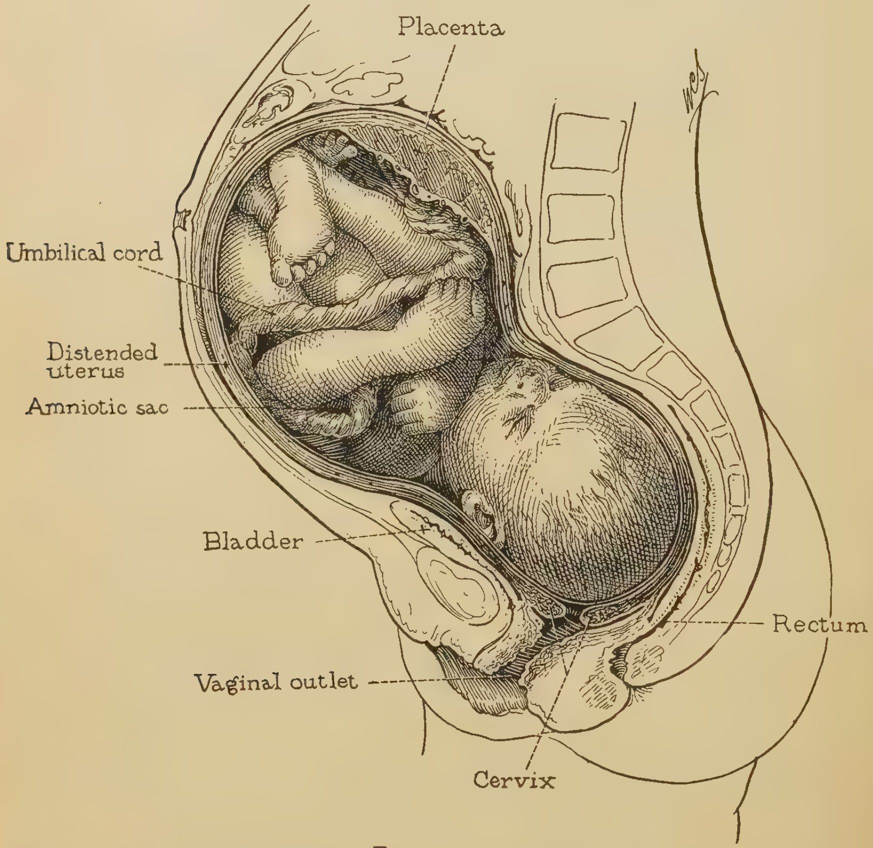

Placenta
Umbilical cord
Distended uterus
Amniotic sac
Bladder
Rectum
Vaginal outlet
Cervix

FIGURE 87

Pregnancy in a late stage just as labour begins. Note the amniotic sac acting by hydraulic pressure to open the mouth (cervix) of the uterus.

The child's head, in the great majority of labours, comes first through the birth canal. This is natural because it is the largest and heaviest part of the child and floats downward in the watery medium of intra-uterine life. It is also a good mechanical arrangement, for the hard, round, large head makes a splendid battering-ram to open the tissues of the birth canal and allow the after-coming parts to be born. When other parts come first, or "present," as the saying is, the labour is more difficult.

The third stage is usually simple and easy. About twenty minutes after the delivery of the child the uterus by mild contractions has squeezed the placenta from its walls as one would squeeze a grape from its skin. It is thrust downward into the vagina, for the uterus is now contracting down and beginning to come back to its natural size, and the placenta is easily removed. At any time after the completion of the second stage the umbilical cord between child and mother may be clamped with a sterile clamp, cut with sterile scissors, and tied on the child's side with a sterile suture. It is dressed with sterile gauze, and the stump soon dries up, separating at the navel.

As soon as the placenta is born, the attending physician, or obstetrician, as we may now call him, has two patients — the mother and child. If the child is breathing well, it may be wrapped in a blanket and disregarded for a time. If it is not breathing, it can be made to do so by a number of simple manœuvres — hanging it by its heels, slapping it on the back or buttocks, putting it in luke-warm or cool water. In most cases it signalizes its change from an aquatic to an aerial existence by a series of gentle sobbing crows, which invariably send the father, unless he has had the experience too large a number of times, into a frenzied ecstasy, leading in the old days directly to the sideboard where the brandy decanter was kept. The mother must be looked to. It must be seen that the uterus is contracting down, its muscular fibres taut, so as to compress the mouth of the open blood-vessels and prevent post-partum hæmorrhage. The obstetrician's hand will be grasping the fundus of the uterus for some time after the delivery of the placenta, as this stimulates contraction. A drug, ergot, obtained from a rust or fungus on rye, has the property of promoting uterine contraction and is often given as a precautionary measure. The condition of the birth canal also needs attention. If the perineum is lacerated, a stitch or two at this time is in order, as the perineum has been made nearly insensitive from the pressure to which it has been subjected. When it is certain that the uterus is well contracted and the perineum in good condition, the mother may have an abdominal binder and a perineal pad adjusted and allowed to rest.

The child must be cleaned. There is always a thick layer of fat on its skin, particularly of the back — the vernix caseosa. This can better be removed with fat or oil than water. The child's eyes should have instilled in each one drop of one-per-cent silver-nitrate solution as a prophylaxis against the blindness resulting from gonococcic infection. Later the eyes should be washed with boric solution.

Food for the child may, but should not, be a source of worry. Mother's milk is by all odds the best nourishment for it. The mother's breasts should begin to fill up and secrete milk on about the fourth day. Before the milk comes in, the child should be put to breast once or twice a day. If there is no mother's milk, artificial feeding of some sort must be resorted to. Wet-nursing is, of course, the best form — the requisition of another healthy lactating woman. If this is not possible, some preparation of animal's milk must be tried.

The formula for artificial feeding varies with every case. Only general principles can be presented here. In doing so I adapt the words of Dr. McKim Marriott of Washington University:

For a normal infant deprived of its mother's milk, weighing within 20% of the average weight for the age, the food should be:

(1) Sufficient to cover the caloric demands.
(2) Capable of supplying at least a certain numerical amount of protein, carbohydrate, mineral salts, water, and vitamins and pigments.
(3) Capable of digestion.
(4) Free from bacterial contamination.

Caloric needs are about 45 C. per pound body-weight a day. Cow's milk will naturally form the basis of the diet, and if one and one half ounces of milk per pound of the child's body-weight be given a day, the protein, mineral salts, and vitamin requirements will be met, with the possible exception of the anti-scorbutic vitamin, which may be supplied by a very small amount of orange-juice or tomato-juice. Boiling the milk will eliminate the danger of bacterial contamination and at the same time render it more digestible. For these reasons boiling of the milk should be the routine for the feeding of any infant, even though the milk be certified. If boiled, undiluted, cow's milk were fed to infants in sufficient amounts to cover the caloric and water requirements, as much as 2½ ounces per pound would be necessary and even then the sugar would be somewhat below the optimum requirement. Some infants can take this much, but the majority cannot. Therefore we must content ourselves with feeding one and one half ounces of milk to the pound of body-weight and make up the calories in another way. This may be done by adding either fat or sugar. Practical experience has shown that the addition of fat in the form of cream or top milk is a somewhat dangerous procedure. A safer method is to add fat in the shape of olive-oil or as a butter-flour mixture. The addition of carbohydrate is the more desirable method of adding additional food to the diet. Sugar or starch or both may be added. There is a theoretical reason for adding milk sugar, lactose, and a commercial reason for the use of dextrin and maltose such as are in preparations of infant foods sold on the market. But cane sugar, which is ordinary household sugar, can replace lactose and corn syrup (Karo) can replace the more expensive malt preparations. More dextrin or starch can be fed an infant without producing diarrhœa than can cane sugar or lactose. Hence the advantage of corn syrup, with its high content of dextrin (55%). Add half an ounce of sugar or Karo during the first few weeks and later an ounce; still later, at four months, 1½ ounces.

About all of this process, the bearing of children and their first days on earth, a process naturally old as the human race, every sort of tradition and superstition has grown up.

The sex of the unborn child has always been an interesting topic of speculation. In Germany in the sixteenth century it was determined by soaking wheat and barley in the urine of the prospective mother and planting both; if the wheat grew up first, a son might be expected; if the barley, a daughter. In south-west France the pregnant woman tosses a coin over her shoulder; if it alights heads, the child will be a boy. If a drop of blood or milk be squeezed from the right breast into a glass of water, the child's sex is determined by whether it sinks or swims.

For sterility the excrement of geese, the shavings of deer antlers, and powdered ivory have been recommended. At the feast of Lupercalia in Rome the priests struck each other with whips; if a barren woman held out her hand and was struck with a whip, her barrenness was relieved.

Abnormal appetites in pregnant women should always be satisfied.[1] Jacob Ruff tells the following story, which may be considered the ne plus ultra of this class:

"A pregnant woman, passing a bakery and seeing the baker naked before the oven, felt an irresistible desire to bite a piece out of his shoulder. But she did not know how to accomplish this, and became despondent and went around for several days without partaking of any food. Her husband was greatly disturbed and tried in every way to induce her to eat. She finally confided that she would be well again if she could only eat what her heart was longing for, and confessed that she desired to bite into the baker's shoulder. The husband promised the baker a certain sum of money if he would let her have her wish, and the baker was persuaded to allow her to bite him twice. But when she insisted on a third bite, the baker bolted on account of the pain. When the woman was delivered, she bore three children, two alive and the third dead."

Maternal-impression stories are numerous. In Ireland, however, if the child is marked with a mole or birth-mark, the blemish will disappear if rubbed with a piece of the placenta. In France a pregnant woman must not be a godmother or her child will be a deaf-mute.

After labour begins, it will be made much easier if the woman slips on her husband's breeches. If labour was delayed, the Spanish midwives placed a hot plate on the woman's abdomen and hit it with the fist. Paulini was of the belief that the dried excrements of pigeons or of wild doves smeared on the abdomen were better than the plate method, although he observes they are difficult to obtain in a hurry when needed, especially "if the patient has no money."

After delivery a sword which has been used to murder someone must be placed in bed with the mother, in order to keep away infection. If the baby sneezes, it is expelling a devil, and "Gesundheit" pronounced immediately prevents the devil's re-entrance into the body. The midwife should spit upon the baby before and after the bath. Why I do not know. But I have often been tempted to do it.

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[1] Remember I am speaking of obstetric *superstitions*.

In many lands, as soon as delivery is effected, the woman gets up and prepares the next meal, while the father goes to bed. He remains there for several days, and even weeks. This custom, known as the *couvade*, or male lying in state, is very sensible.

But one need not go to far lands or far times to find obstetrical superstitions. One of my obstetrical friends has compiled a list from my own enlightened community, where it is believed that pop-corn is good for the nausea of pregnancy; that if a menstruating woman touches a mare which is with foal, the mare will miscarry; that she must not handle milk or it will turn sour; that she must not attempt to make jelly or it will not solidify; that if the mother has indigestion during pregnancy, the baby will have a great deal of hair; that if a woman goes overtime in her menstruation it can be remedied by dropping new pennies on the floor; that if the father will go to bed on his wedding-night with his boots on, the baby will be a boy; that if the mother eat freely of peanuts during her pregnancy, a girl will be forthcoming; that if the expectant mother touch her face as a habit, the baby will be birth-marked on the face; that if bleeding occurs after delivery, an ax, edge up, should be placed under the bed; that after delivery the mother should always go downstairs for the first time backwards; that if the baby has convulsions, salt should be placed on the palms of its hands; and that the baby's finger- and toe-nails must not be clipped during the first year or it will turn out to be a thief.

Considering how inevitably associated the process of birth must have been with the earliest attempts of the human mind to solve nature's problems, it is remarkable how late in human history the application of scientific methods to it was made. Scientific obstetrics was one of the latest branches of medicine to develop. Every sort of prudery was invoked to prevent any knowledge of it. On Egyptian wall-paintings and in the articles and miniature representations of life in Egyptian tombs every possible aspect of their life seems to be recorded. There are pictures of people with infantile paralysis, there are delineations of many other diseases. But representations of the lying-in chamber are wanting. During the Middle Ages and Renaissance we find some — majolica plaques with pictures of the mother in bed and the attendant bathing the new-born baby, testing the temperature of the water with her bare foot. But even up to the seventeenth century it was considered improper and indelicate to admit a man, a physician, to the presence of a woman in childbirth. Midwives flourished and retained all the knowledge of obstetrical procedure in their own hands. And there was not a little reason, as we shall see, on the side of this attitude. Even as late as 1817 in England when Princess Charlotte and her child died under the care of Sir Mathew Baillie and Sir Richard Croft, feeling was so strong that two years later a German midwife was imported to bring the future Queen Victoria into the world. Napoleon selected a midwife, Madame La Chappelle, to assist Dr. DuBois in accouching Marie Louise on the occasion of the birth of the Duc de Reichstadt.

There is an old pamphlet, the memoirs of Louise Bourgeois, midwife or *sage-femme* in Paris (1590 to 1630), which tells of the birth of a dauphin, who was afterwards Louis XIII, his father being Henry of Navarre, and his mother, the lady in labour, Marie de' Medici. Nothing so vividly takes us back to the life and manners of those days as this sprightly narrative of the lying-in chamber at the court at Fontainebleau. How she was selected to attend the august couch is itself a pleasant tangle of intrigue. The selection, indeed, was simply a selection between midwives, for no woman of respectability, especially a queen, could consent to allow a male accoucheur access to the lying-in chamber. Not until 1663, when Louis XIV employed Julien Clement to attend the confinement of Mademoiselle de la Vallière, did a King of France consider admitting a man to the accouchment even of his mistress. In 1522, indeed, a Dr. Wirtt was burned alive at Hamburg for assisting at a delivery disguised as a midwife. He was a true medical martyr because he was really trying to find out what happened during a labour; in those days even medical men did not know.

Henry IV then had only midwives to select from. Although his first wife, Marguerite de Valois, had borne him no children, the sovereign was not unacquainted with the mysteries of the delivery room. Many, if not most, of his experiences concerned the beautiful Gabrielle d'Estrées, who had presented him with a number of bastards, one of whom, the Duc de Vendôme, plays a role in the narrative of Louise de Bourgeois. The lovely Gabrielle had, however, carried the pitcher to the well once too often. In 1599 she had died of puerperal convulsions, being attended by a certain *sage-femme jurée* of the city of Paris named Mme. Dupuis. When in the following year Marie de' Medici was reported *enceinte*, the King immediately engaged the services of Madame Dupuis. His new queen, however, could not be expected to accept calmly the services of the midwife of his deceased mistress, and, acting on advice, she consulted Louise Bourgeois. It took Marie "but the space of a paternoster" to form a good opinion of Louise's abilities and to engage her. Whether or not the King protested is unrecorded; but his new wife had always had a villainous temper, and was moreover in that condition which husbands are always warned to regard as particularly deranging to mental equipoise, and it is hardly likely that a man who could complacently join the Church of Rome because "Paris was worth a mass" would be so unwise as to oppose his new queen's choice of an obstetric attendant.

Louise Bourgeois, then, when the occasion required, was conveyed to Fontainebleau in the royal carriage. The journey required three days. On the night of September 26th she entered the Queen's apartment and found the labour in progress. The King warned the midwife and the Queen that the Princes of the Blood Royal must be present during the actual delivery, and cautioned that they must be told in good time. This was of course for the reason that they could attest the legitimacy of the future king of France. Shortly after midnight they were sent for — the Princes de Conti, de Soissons, and de Montpensier. While waiting for them the King said: "If ever anyone has never seen three princes in deep trouble, one will soon see them now. These are three princes very full of pity and good nature who, seeing my wife in labour, would give most of their possessions to be far away from here." It does not appear from the record that the princes were as overcome with the emotional excitement of the ordeal as their royal kinsman anticipated. Doubtless they, like him, had sufficient vicarious obstetrical experience to have become inured.

In the mean time the great bedroom of Fontainebleau was prepared. A bed of crimson velvet ornamented with gold was brought close to the bed of accouchement. Over the bed of accouchement was hung a pavilion and inside this the midwife and her patient, with the princes, were concealed, while outside the court gathered. When the Dauphin was born the midwife placed him in his linen wrapper so that his sex was concealed. The King looked at the child's face and supposed from the smallness of the features that it was a girl. He walked away, buried his face in his hands and refused to be comforted, A male heir was badly needed. The midwife asked for some wine and said to the King: "Sire, if it was any other child, I should put the wine in my own mouth first and give it to him that way, because of his great feebleness." The King put the bottle against her mouth and said: "Do to it as you would to another." When His Majesty was convinced that it was a son that was born, "the tears rolled down his cheeks as big as large peas." The poor little Duc de Vendôme, son of the lost Gabrielle, was found by the good woman in a corner. "No one pays any attention to me any more," he said; he had been the darling of the court. When the Queen heard of this, her heart was touched and she ordered everyone to pay especial attention to him — "to caress him as formerly." How delicious these brown old pages are. Nothing is so human as obstetrics.

The customs that these records reveal of the employment of midwives in royal households naturally were reflected in humbler dwellings. Not until the middle of the eighteenth century was the attendance of men at labours at all usual. A famous family of obstetricians of the seventeenth and eighteenth centuries was the Chamberlens. They are credited with the invention of the obstetric forceps. The brothers who founded the family boasted that no one excelled them in the handling of difficult labours. They kept their invention a secret. Many attempts were made to discover it. It was, however, kept for many years, passing from father to son. Finally one scion of the house, Hugh Chamberlen, probably being hard up, determined to cash in on the well-kept secret and went to Paris, where he offered it to Mariceau, the foremost French obstetrician of that day, for ten thousand dollars. Mariceau demanded proof that Chamberlen could actually assist in very difficult cases and, happening to have a deformed dwarf in labour, asked Chamberlen to attempt to deliver her. He failed utterly, the patient dying from a ruptured uterus, and Chamberlen returned to England. Here he translated Mariceau's book, announcing in the preface: "My father, brothers, and myself (though none else in Europe that I know) have by God's blessing and our industry attained to and long practised a way to deliver women in this case without any prejudice to them or their infants." Even with such publicity the secret of the obstetric forceps was kept and a thousand faked revelations of it brought their perpetrators tidy sums. Finally Hugh Chamberlen sold the secret to the College of Physicians at Amsterdam, and the College induced the Government to pass a law that no one could practise medicine in the city unless he had taken the course of instruction in obstetrics in the College. At last two citizens of Amsterdam, outraged at this venal traffic in a method which should be known to all mankind, took the course in medicine at the College and published the long-

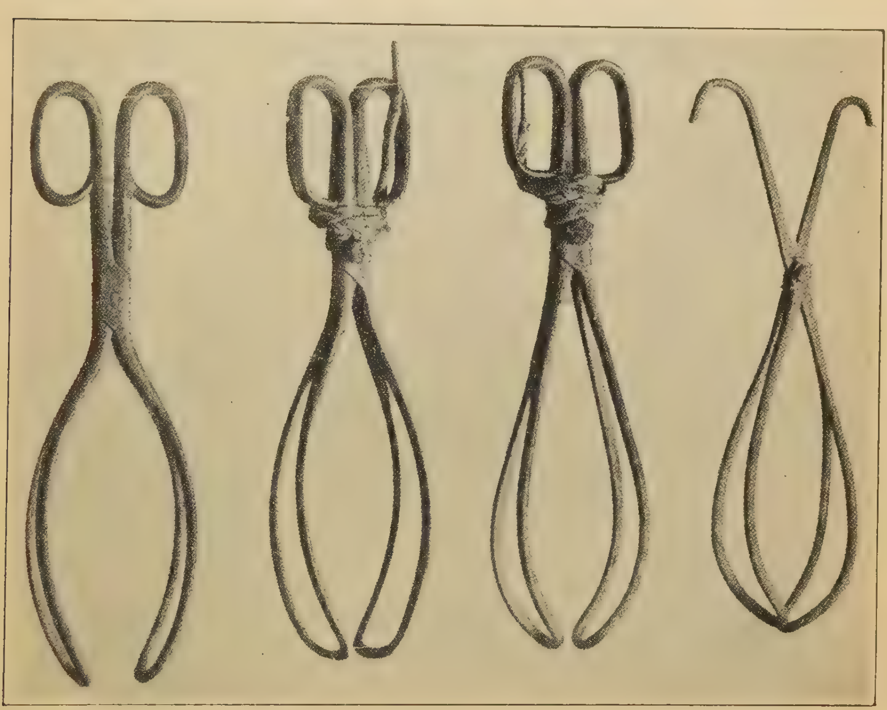

FIGURE 88

The original Chamberlen forceps. Discovered in a chest at Woodham, Mortimer Hall, Essex, in 1813.

kept secret. It turned out to be a single blade of the obstetric forceps. Whether Hugh Chamberlen tricked the College by selling them only one blade or whether the College tricked its students will never be known. By this time, or shortly after, the entire secret was out and the forceps have been used ever since. For many years no one ever saw one of the forceps which the Chamberlens actually used, but in 1813 at Woodham, Mortimer Hall, in Essex, which had been owned by Peter Chamberlen, in an old chest, were found four pair of forceps used by the Chamberlen family. They are not unlike the obstetric forceps used to-day.

We said above that there were good reasons why people even in the nineteenth century should continue to employ midwives. The reason for this lay in the ghastly death-rate among women confined by men physicians. The cause of death was almost always puerperal sepsis or childbed fever. The reason why physicians infected more patients than midwives was, as we now know, that their hands would dabble in pus and in septic material at post-mortems and they would employ no methods of sterilization before examining women in labour. But the possibility of such a thing as obstetricians' infecting their patients with their own hands, first suggested by Oliver Wendell Holmes in 1843, was resented by every teacher of obstetrics in the world. Hear the words that Charles D. Meigs, professor of midwifery at Jefferson Medical College in the enlightened city of Philadelphia, wrote in answer to Holmes's paper "On the Contagiousness of Puerperal Fever", "I prefer to attribute," says the professor, with his flair for sarcasm, "them [i.e., deaths due to childbed fever] to accident or providence, of which I can form a conception, rather than to a contagion, of which I cannot form any clear idea." And so it went, the professors laying the blame on providence, or the suppression of milk, or a thousand other things of which they could form a conception.

In Vienna in 1846 was a young assistant at the General Hospital, named Ignaz Semmelweiss. He is a hero of medical science. He became oppressed with the incidence of puerperal fever in one of the maternity wards. In a neighbouring ward the death-rate from this cause was one tenth as great. In the first ward the women were attended by students. In the other by midwives. Semmelweiss noticed that in the first ward the students came fresh from the post-mortem room, where they had been handling diseased tissues, to the bed-side of the parturient women. He conceived the idea that they carried putrid material on their hands and that this was the cause of childbed fever. He ordered every student to wash his hands in chlorine water before he attended a case of labour. A basin of chlorine water was placed in the entrance doorway of the maternity ward. In two years the deaths in that ward fell from 459 to 45. Did the world greet the announcement of this discovery of Semmelweiss with acclaims of happiness? It did not. "What?" cried the professors of obstetrics, "we cause puerperal fever in our own patients? Absurd! Impertinent!" The vials of their wrath were poured upon the head of Semmelweiss. Still he pointed out that in August 1848 — 1848 was the year of revolution in young Europe — when all the students were too busy on the barricades to attend the women in the *Krankenhaus*, there was not one single death from childbed fever. Some adherents he gained. Professor Michaelis of Kiel was one. Michaelis attended his own niece in her confinement; she died and Michaelis believed enough in the doctrine of Semmelweiss to think that he killed her, and threw himself beneath a locomotive as a sign of his sincerity. Even with so prominent a martyr the doctrine made little headway. "To be laid on the confinement bed," said a physician of the times, "was the same as to be delivered to the hangman." From 1860 to 1863 no lying-in patient left the hospital of the University of Jena alive. "All died of puerperal fever." Semmelweiss published a book, went decently mad, stopped people on the street to harangue them about childbed fever, and finally died in an insane asylum. Pasteur demonstrated something concrete in the way of contagion for the professor of midwifery at Jefferson to form a conception of, and obstetrics, like surgery, was put upon an aseptic basis. I know men who have practised obstetrics twenty years and have never seen a case of childbed fever.

In the hands of men, indeed — that is, after it was removed from women, midwives — obstetrics graduated from an art to a science. The forceps, asepsis, podalic version, the measurement of the pelvis — all these came from men. Finally the introduction of an anæsthetic! On the evening of November 4th, 1847, a curious scene could have been witnessed in the back room of a surgery in Edinburgh. James Y. Simpson, professor in the department of obstetrics in the University, and his two assistants, Keith and Duncan, were inspecting a brown bottle containing a heavy liquid. They had been told by a Liverpool chemist, Waldie, that the liquid, chloroform, might have soporific qualities. Simpson had been looking for an anæsthetic to be used in cases of confinement. He had tried ether but found it too slow in action and inhibitive to the pains of labour. The three experimenters poured the chloroform into three saucers and began to inhale. Remember when you think of these men that they knew nothing of the properties of the substance they were trying. It might kill them for all they knew to the contrary. Animal experiment, except on *homo sapiens*, was temporarily taboo in Edinburgh. But they inhaled. Dr. Keith suddenly began to laugh. The laugh was infectious; Mathews Duncan and Professor Simpson joined in. The professor attempted to stand on his head. His wife opened the door, and at this interruption of his acrobatics the professor collapsed gently on the floor and began to snore. When he awoke, he blinked his professorial eyes and said with professorial calm: "This is better than ether."

CHAPTER IV

THE VENEREAL DISEASES

There is no reason why gonorrhœa and syphilis should be treated under this section — they belong by right with the account of the infectious diseases — save that in the great majority of cases they are acquired in the performance of the act of reproduction.

Gonorrhœa has been known from the earliest times. It is caused by a paired germ, the gonococcus. It affects the mucosa of the genital tract in both sexes, causing a catarrhal discharge of pus. In males it affects particularly the urethral canal, being in fact a urethritis. It may extend backward to the base of the bladder and even into the testes. In the female it affects the vagina, the opening of the bladder, and the crypts around the cervix. It goes backward into the uterus and tubes, causing a very serious localized peritonitis and often sterility. If a woman is infected at the time of confinement, the germ may get in the baby's eyes and cause blindness. It is one of the most serious and devastating of all diseases.

Prevention is possible. Public prevention can never be accomplished until prostitution, especially irregular prostitution, is abolished, which I suppose everyone admits is an unattainable ideal. The public regulation and supervision of prostitutes has always been prevented by the false sanctimony of public opinion. Christian ministers would always prefer to have boys diseased, women ruined and made barren, and babies blinded than admit that the seventh commandment was ever broken by any of their flock. Individual private prevention may be accomplished by the instillation into the urethra of a 25% solution of argyrol within a few hours after a suspicious intercourse. The success of this method depends upon the widest dissemination of the information contained in the preceding sentence and implicit faithfulness in carrying it out. Both are difficult of accomplishment.

Even in the army of 1917–1919, where the instruction on the subject was universal and inspection and rigid insistence on prophylaxis carried out, the incidence of venereal diseases was sufficiently high to be troublesome.

Syphilis has a very hard name — a much worse one than it deserves. It is, after all, not such a very dreadful disease. We hear about or see all the bad cases. How many people have it and are not even aware of it, much less any the worse for it, would be hard to say. The general incidence of it in the population is said to be 7%. It has not always affected the human race. Tradition says that it was acquired by Columbus's sailors from the Indian maidens in America and so introduced to Europe. The evidence on the subject is very confusing. But it is certain that we have no indubitable references to it or descriptions of it before 1450.

The cause is an animal parasite — the spirochæta pallida. It is a corkscrew-shaped animal which moves incessantly under the microscope. After infection the disease itself is usually divided into three stages. The initial change is characterized by the appearance of a sore, the chancre, which forms at the point of entrance of the causative organism. The entrance is effected in some break or abrasion of the skin. Chancres usually form on the genitals, but may form on the lips or tongue or, in fact, anywhere on the external part of the body. A chancre forms about six weeks after inoculation. By the time it forms, the spirochæta has spread to all parts of the body.

The second stage is a general eruption on the skin of the body and may be in the form of (1) faint pink or reddish splotches, macules, or (2) raised red lumps, papules, or (3) raised lumps containing pus, pustules. The inside of the mouth at this stage has greyish spots — the mucous patches. The hair may fall out owing to the presence of spirochætæ around the hair follicles. This is the stage of highest infectivity.

The third stage includes all the late manifestations. One lesion of this stage is the gumma — a breaking down of tissue, which may range in size from that of a pea to that of a football. The liver, the bones, the meningeal covering of the brain, the skin, and the spleen are favourite sites for gummatous formation. In the third stage the blood-vessels, particularly the aorta, may become affected. Aneurysm can result from such changes. The

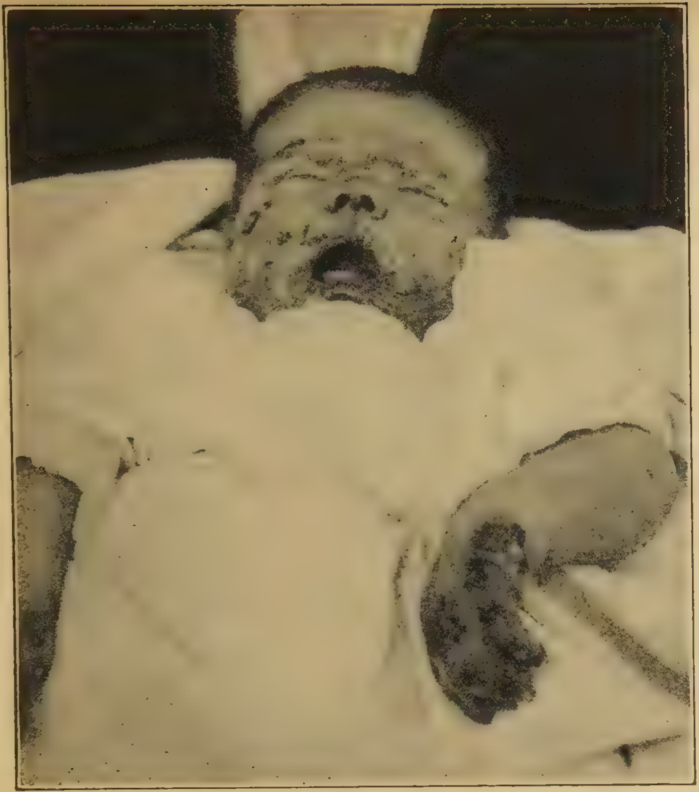

FIGURE 89

Congenital syphilis. Before treatment.

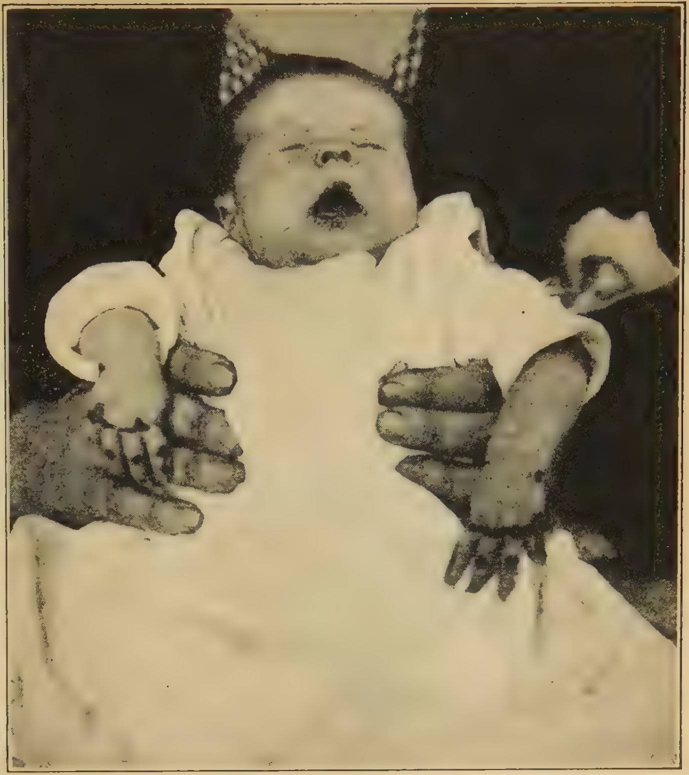

FIGURE 90

Congenital syphilis, same infant as shown in Figure 89. After treatment. One week after a dose of neo-salvarsan in the vein.

nervous system is affected probably by a special strain of the spirochæta, causing locomotor ataxia and paresis as well as a number of less generally familiar syndromes.

Congenital syphilis is the result of infection carried to the child inside the uterus from the infected mother. The spirochætæ travel through the placenta and enter the child's blood-stream in this way. The baby may be born with extensive skin eruption. A stunted growth, mental retardation, bone changes and peculiar changes in the teeth — Hutchinson teeth — are other forms of congenital syphilis. The disease may affect one of a pair of twins, leaving the other twin entirely normal.

The treatment of syphilis, if the case is obtained early enough, is quite satisfactory. Even for the late cases much can be done. The first drugs used were mercury and iodide of potassium. Mercury will kill the spirochæta just as quinine kills the malarial parasite. Iodide of potassium is particularly effective in the treatment of gumma. These large tumours melt away under its use. Many of the fake cancer cures heard about are the result of the use of this drug on gumma. The most effective treatment of the earlier stages is by use of the drug variously known as "606," salvarsan, or arsphenamine, introduced about 1910 by Ehrlich. Ehrlich was a most prolific research worker who became obsessed with the idea of affinities in the chemical world. It was he who found that by combining a blue dye with a red dye for staining blood, the blue dye would stain the nucleus of the blood-cell, and the red dye would stain its cytoplasm. He conceived the idea that a drug could be found which would be very deadly for the spirochæta of syphilis but which would not injure the human tissues where it lived. The result of his work was the discovery of an arsenic compound — which he named salvarsan. Because it was the six hundred and sixth trial he made, "606" became its popular name.

Individual prophylaxis of syphilis is accomplished by using a 30% ointment of calomel smeared on the parts after suspicious contact. The public prevention of syphilis is identical with the public prevention of gonorrhœa.

A method of examination of the blood, the Wassermann reaction, has been developed to detect the infection of syphilis in any human body. The reaction is quite complex. In general, it may be said, it depends upon the fact, well known in other contagions, that when a syphilitic infection occurs, certain immune substances are elaborated in the blood of the infected individual. The nearest analogy we have is the Widal reaction in typhoid fever. The Wassermann reaction is, however, not nearly so well standardized nor, hence, so accurate as the Widal. Some people have positive Wassermann reactions who have never had syphilis. The reaction in the early cases tends to disappear under vigorous treatment. In some patients, on the contrary, it persists through life, marking the fact of the original syphilitic infection, just as the Widal reaction marks all through life the single typhoid infection. These late and Wassermann-fast individuals seldom have their Wassermann reactions changed by treatment.

PART IV

THE HUMAN BODY AND DISEASE

CHAPTER I

THE NATURE OF DISEASE PROCESSES

There is, so far as I am aware, no simple explanation for the untrained reader of the tissue changes in disease; no pathology for laymen. If such an inquirer wishes to obtain information about so important a matter as, for instance, the nature of tumours or new growths, his only recourse is the encyclopædia, where he finds a highly technical and, because he usually seeks it for personal reasons, a very alarming account of the subjects in which he is immediately interested.

In those courses and text-books on "physiology and hygiene" prepared for school-children it is not thought necessary to present anything other than the normal activities of the body, and though there is some account of bacteria, the tissue changes which lie at the root of disease processes are not considered formally at all.

To this circumstance I am inclined to ascribe the astonishing ignorance on the subject of the nature of disease manifested by otherwise well-informed people. That such ignorance exists I recently took occasion in preparation for this chapter to demonstrate. I asked a group of fairly intelligent and educated people to define for me what disease is. They were not extraordinarily well educated nor highly intelligent people, because I did not wish to select such a group. None, naturally, had any medical training. All were parents, and had the custody of small human bodies liable to disease. All were approaching or had reached that fatal decade when, according to rustic proverb, a person is written down either as a fool or a physician. Yet, with all these responsibilities and opportunities, their ideas on a subject of vital importance to all of them were simply silly. A favourite form of reply was "Disease is an unnatural occurrence in the body." When it was pointed out that "unnatural" was a somewhat unsatisfactory term — that, for instance, the growth of typhoid bacilli in the body was perfectly natural for the typhoid bacilli — the definition was amended to "Something which enters the body from the outside," or "A deviation from the average course of life," both of which have easily demonstrated deficiencies.

The discussion brought to light three outstanding misconceptions. Disease was considered by all to be (1) "harmful," (2) "unnatural," and (3) "lawless," or not acting in accordance with regular, discoverable rules.

Concerning the first of these ventures at definition, far from being "harmful," the great bulk of the changes in the body in disease are distinctively protective. They constitute the best defence, the best adjustment which the body can make to the inroads of the external world. We shall presently examine some of them in detail. I mention one or two now to make my point specific — wound healing, enlargement of the heart (to overcome mechanical derangement or high pressure), the formation of stones (which engulf and encyst bacteria and foreign bodies), the knitting of bones, pain (which prevents a part which is injured from being moved) — all these are distinctly protective and helpful, not harmful.

By "unnatural" my class meant, so far as I was able to disentangle their meaning, a divergence from the normal course of things. A human body which is "normal" does not have disease, that was the idea. It is an idea, of course, which is repeated in half-baked philosophies of disease, in the brochures which cranks write, in the religions which half-baked intelligences profess. "God did not intend disease to enter the world." It is an idea which is very agreeable to any human mind. But it is totally false. There is not one human body which lives ten minutes beyond birth which does not become the subject of disease. The body is born into a world which was not made for its comfort, which was not designed for its safety. Every sort of malignant force is lying in wait to pounce upon it — bacteria; the surface of a hard object, such as the floor; fire, water, poison, sun, cold, storm, lightning, and hurricane. All of these and others far more subtle — the inherent tendencies of the body's own cells, to cancer, sclerosis, pernicious anæmia, and hæmorrhage — are just as "*natural*" as the human body is itself. Disease is the interaction between these objects and the body's defences — and is perfectly normal and natural.

And as to "lawlessness," the laws of disease are as definite and well known as those of any other biological process. Pathology, the study of disease, is a science using the scientific method, which according to Karl Pearson (*Grammar of Science*) consists in three steps: (1) the collection and recording of facts; (2) the classification of these facts into series or sequences; (3) the discovery of a short formula or "scientific law" which will enable us to describe these sequences of facts in the most comprehensive and convenient manner.

No one in my group hinted at an acquaintance with the methods by which disease processes are studied, or of how such information as we have about them was obtained. There was one definition obviously a reflection of the osteopathic and chiropractic systems of pathology, that disease was interference with proper nerve functioning or blood-supply to a part. The propounder of this edict interested me so sufficiently that I pressed him to say how he thought a knowledge of the nature of disease was arrived at; and I gathered from an exceptionally confused answer that he thought some physician would get an idea about it and proceed to study sick people until he had proved or disproved his idea. Pathology is, however, one of the inductive sciences.

How did men learn about disease? How did they rescue pathology from the priests? It has been a long story so far as the time involved is concerned. They went at it in various ways. Let me hint at some of them.

On the wall of an Egyptian tomb there is a painting with many human beings represented. One of these has a wasted leg. We in our day and age can look at that picture and say that the youth there represented had infantile paralysis. We know, just as surely as we know that the model of the sheaf of wheat held in the hands of another member of that painted group was grown from seeds put in the ground, that a certain portion of his spinal cord was affected in a certain way. But what do you suppose the ancient Egyptians thought about him? Can't we imagine them wondering how the inside of his body was changed from the average? But they had no way of finding out. The priests would not let an inquirer cut the body up after death, all he could do was to record the external change.

For long centuries all that pathologists could do was to classify the external changes which they could observe about the body, and amalgamate the similar ones into groups. When a definite set of symptoms was found to recur without variation or with only small variation, a name was given to it. Thus Sydenham named measles and separated it from scarlet fever, on the basis of the difference in the appearance of the eruption and attendant symptoms. To this method of pathologic study belongs the description of diabetes by Aretæus the Cappadocian already quoted, as "a melting down of the flesh into urine." After diseases were thus classified and named, the course and outcome — the frequency of death — of a set of symptoms or syndrome were charted. When the disease process was on the surface of the body or near the surface, as with infected wounds, or skin cancers, or tonsillitis, some idea of the gross tissue changes could be formed. But supposing the processes to be hidden in the internal organs; up to the time well beyond the Renaissance the ban against dissection of human bodies prevented any examination of the deeper structures after death.

Naturally such conditions gave rise to a phantasmagoria of personal theories about disease and systems, elaborated by individual physicians. These theories or systems have a certain melancholy interest for us yet, because they so closely resemble the healing cults of our own day — homœopathy, eclectic, chiropractic, osteopathy, Abramsology, etc. The intellectual processes in all cases are identical. The systems are all deductive — they begin with a theory and then try to gather facts to prove the theory. If they find a fact which does not support the theory, they treat it with aristocratic indifference — as if it did not exist. For the systems of an earlier day there is some excuse — the men who formed them had no access to post-mortems, there were no microscopes, they knew nothing of bacteriology or of physiologic chemistry. But for the theorizers of our own time there is no such justification. Let us glance at some of the delusions about the body with which man has been afflicted in other centuries. Remember as you do so that thousands upon thousands of people believed them. But do not assume any air of superiority: examples of credulity upon the same subject are plentiful all about you here and now. Van Helmont (1577–1644), for instance, developed the Iatro-chemical school. He taught that every physiological process was presided over by a special spirit, and used a special ferment or gas in accomplishing its function or dysfunction. These founders of systems gathered to themselves enormous reputations both as healers and as teachers. Boerhaave (1668–1738) had probably the widest popularity as a physician between the times of Galen and the Mayo brothers. A Chinese official once sent a letter, so the legend goes, "To the most famous physician in Europe," which was duly delivered to him. He made Peter the Great wait all night to see him because he would make no distinction between his patients on the ground of wealth and power. His system was the Eclectic (not to be confounded with its American namesake), based largely on an "affinity" between various substances. "His prescriptions were less effective than his personal appearance." Another interesting and famous figure in his time was John Brown (1735–1788), whose "Brunonian System" caused so much disputation that twenty-two years after Brown's death an argument between Brunonian and non-Brunonian students at the University of Göttingen required the aid of a troop of Hanoverian horse for its suppression. The system was based on the excitability of various tissues: diseases were accordingly "sthenic" or "asthenic," remedies stimulating or depressing. If you had a sthenic disease, you gave a depressing remedy—opium. A delightful prelude to his entire theory is the statement that life is not a natural condition. Dear old Hermann Baas, the raciest of medical historians, avers that the Brunonian system would have sacrificed more lives than the French Revolution and the Napoleonic wars combined if it were not for the body's unexampled ability to recover "from the faults of the physician."

This orgy of speculation about disease was gradually brought to an end by the introduction of the true scientific method of pathology — the observation of symptoms during life compared with and checked by the examination of the body after death. The method of the post-mortem! Many isolated accounts of post-mortems exist before his time, but to Théophile Bonetus, to give him the Latinized name he assumed, must be credited the first systematic account of a long series of autopsy records, covering all the symptoms and disease syndromes of the body. His work, the *Sepulchretum*, was published in 1679.

The *Sepulchretum* begins at the top of the body with an account of headache. Various kinds of headache are described, and then a series of post-mortems recorded with a detailed account of the appearance of the internal organs in the different cases. Theoretical observations are few. The plain facts are set forth.

A far more acute observer than Bonetus was the great Morgagni, who can truly be called the founder of pathology. His book, *De Sedibus et Causis Morborum* (*The Seats and Causes of Disease*), was published in 1761. It purports to be a series of letters written to a young student of Padua; it follows the general line of Bonetus's work — the record of symptoms in a patient, and the observation of the organs of the body after death. Morgagni was, however, a better observer and more practised dissector than Bonetus. He was the first to show that mastoiditis and brain abscess followed suppurative ear disease. He demonstrated that in apoplexy the hæmorrhage into the brain is on the opposite side from the paralysis. Another great pathologist was Matthew Baillie, who lived at the beginning of the nineteenth century and from whose book on *Morbid Anatomy* I reproduce one of the beautiful and accurate plates (Figure 91) to show how precisely these men could record the gross changes of disease.

An important advance came with the perfection of the microscope. As has happened so often, advance in one science depended upon invention in another. The compound microscope was brought to its present state by the inventive genius of Wollaston and Jackson Lister in the first two decades of the nineteenth century. The immediate result to biology was the cell doctrine, the development of embryology as a science, and the establishment of histology, or minute anatomy. Histologic methods consist in hardening a piece of tissue in alcohol, imbedding it in paraffin wax or some similar substance, and cutting it into very thin, transparent sections; these sections are stained with two dyes, one blue, which colours the nucleus, and one red, which colours the cytoplasm of the cells. Placed under the microscope, the tissue is seen in terms of its units — cells.

Pathology naturally followed the methods of histology and placed diseased tissues under the microscope. The epoch-making event in this period of its development was the publication in 1858 of Rudolph Virchow's *Cellular Pathology*. Note the title. It was a treatise on the processes of disease in terms of cells and cell activities. The influence of this work and the influence of

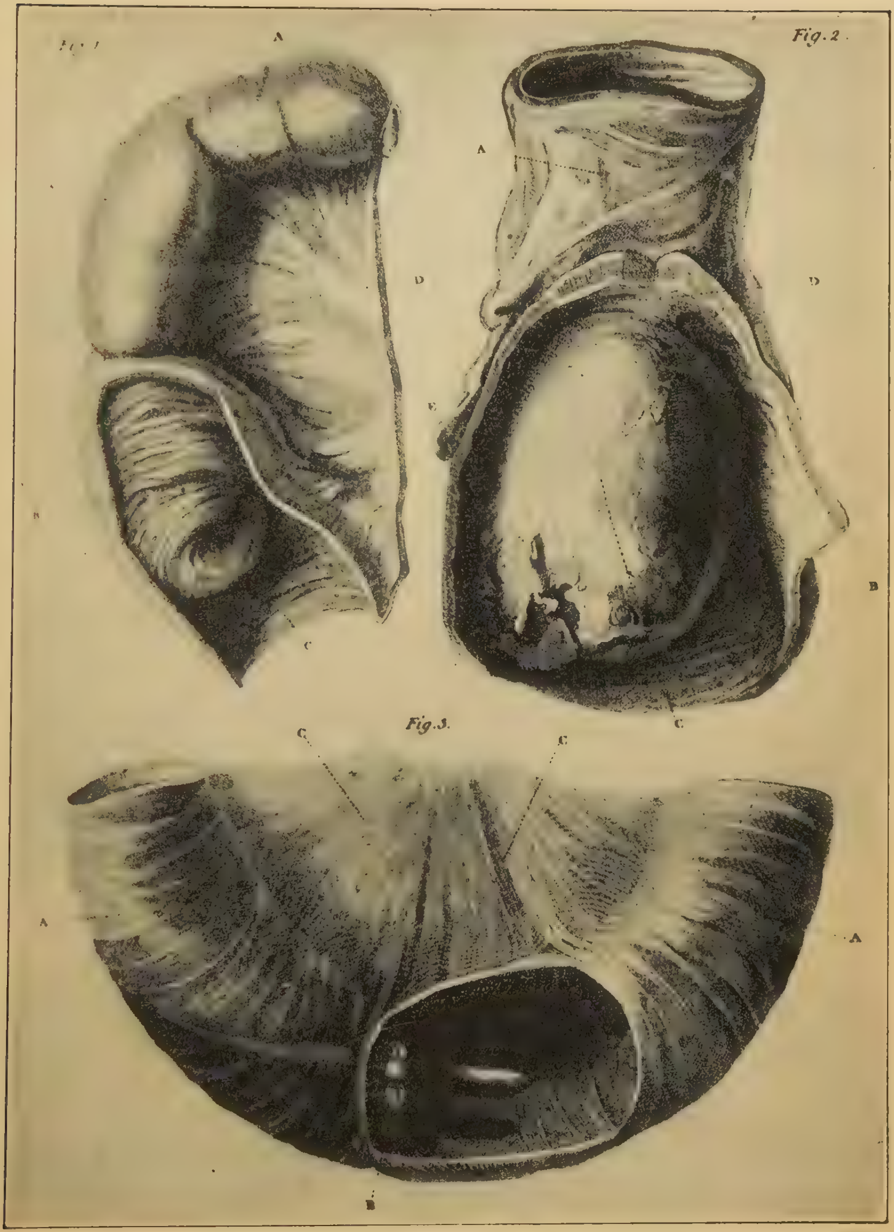
Fig. 1
A
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FIGURE 91

Representations of intestinal obstruction from Baillie's "Morbid Anatomy."

its author on medical, in fact scientific, thought can hardly be over-estimated. Before its publication Virchow had established in 1847 a magazine, the *Archiv für pathologische Anatomie*, which for the eleven years before the publication of the *Cellular Pathology* continued to publish study after study of the pathology of various diseases. In the opening number he declared that an unproved hypothesis in medicine should never be used for building any theoretical doctrine. No more significant statement of the aims of scientific medicine to-day could possibly be found.

The body, according to Virchow, is "a cell state in which every cell is a citizen." Disease, then, is "a conflict of citizens in this state, brought about by the action of external forces." The cells which he found in the body in disease were exactly the same as the cells found in health. They were simply modified in their activities — that is, in rate of growth or situation (blood-cells outside the capillaries in inflammation) — from the normal. Virchow's great biological pronouncement was "*omnis cellula e cellula*" — all cells come from pre-existing cells. Therefore diseased cells must have normal cells for ancestors.

The gigantic value of the *Cellular Pathology* was the unprecedented thoroughness with which Virchow examined every tissue in every disease. The work still stands there, quoted by writers to-day as if it were a modern text. What Virchow said about leukæmia, the giant cell in tuberculosis, embolism, cancer-cells, cancer metastasis, myocarditis, lupus, thrombosis, inflammatory wandering cells, and a host of other topics is considered as important to-day as the opinion of any living pathologist. Since his day pathologists have picked up a few new wrinkles in technique, have added here and there a few odds and ends, but the science of microscopic pathology was born full-grown in 1858.

These labours laid the foundation for any true knowledge of disease. But it must be evident that they left great lacunæ. The changed anatomy of a part is not all there is to pathology. Granted, for instance, that a man who had suffered from a swelling in the abdomen, sweats, and fever, was found after death to have a collection of pus in the liver, the question arises "What caused the pus to form there?" In short, morbid anatomy is the first step in uncovering the nature of disease, but it does not reveal in itself the *cause* of the changes in the organs. Again, granted that a man who has suffered in life from dropsy and who finally lapses into unconsciousness is found to have large, pale, diseased-looking kidneys, the question arises "How did the kidney-change cause him to become unconscious and to accumulate fluid in his tissues?" Morbid anatomy throws no light, then, on the chemical or toxic changes in the fluids or functions of the body after disease begins. Such problems have held the attention of research workers in the years between Virchow's time and ours. The development of bacteriology by Pasteur and his disciples, the discovery that minute vegetable organisms entering the body initiate so many of the changes which puzzled the older speculators, has furnished a satisfactory statement of the cause of many diseases. The growth of other sciences — of chemistry and physics particularly — has enabled special students to study the changed chemistry of the blood and of the tissues of the diseased body.

Thus "pathology" to-day includes not only a knowledge of the appearance of diseased tissues — pathologic anatomy — but also of the actions of those agents which initiate pathologic tissue changes — bacteriology, parasitology, toxicology, etc. — and of the nature of the changed functions, secretions, and chemical reactions of the body in disease — pathologic physiology.

This historical sketch has clarified, I hope, those conceptions of the idea of disease which my group of acquaintances advanced. Disease processes are not "unnatural." They are the perfectly logical result of the activity of external forces, of the processes of growth and the progress of time. They are, in many instances, protective devices — the attempt on the part of the body to preserve itself from being overwhelmed by the rest of nature. The line between what is health and what is disease is so vague, as we shall see in the next chapter, as to be imperceptible. Finally disease processes follow well-known and recognizable laws of nature. Serious enterprises, such as surgical operations, can be undertaken with a knowledge of the natural laws of disease, in the certain consciousness that if these are not violated success will result.

CHAPTER II

REPAIR, HEALING, AND INFLAMMATION

If a surgeon makes an incision in the skin over a portion of the abdomen with a clean knife, and after his work is finished, the two edges of the cut skin are brought carefully together, it is well known that a series of changes occur which result in complete healing or repair of the part and a close union of the cut edges. If a census were made of fifty thousand people, forty-nine thousand seven hundred and fifty, at the outside, would not have a scar at exactly that point on the body. Of the two hundred and fifty who have it, not more than ten would have that particular incision undergoing the various stages of repair at exactly the same time as the case under consideration. From the standpoint of its being a departure from the average or normal, therefore, the condition must be called disease. If, however, the processes of repair did not take place, the individual would die, or at least be considerably crippled. From the standpoint, therefore, of its being harmful, as disease is supposed to be, the process is distinctly helpful, protective, and physiologic rather than pathologic. Nothing could illustrate better how difficult it is to define disease or how wide and vague are the boundaries which separate disease from health.

The changes which occur in this incised wound are typical of one of the basic pathologic processes, called inflammation. They can be observed to some extent with the naked eye. For the first few days the skin bordering the incision is reddened and swollen, bulging up from the rest of the skin area, and pushing up over the stitches holding the two edges in place. This phenomenon of *congestion* corresponds to the appearance under the microscope of a great dilatation of the blood-vessels, and an apparent increase in their number. Apparent increase because the new vessels which are seen in an inflammatory area are capillaries which under normal conditions were empty and functionless, and therefore invisible, but which are now choked with blood. If living tissue which is transparent enough to be observed under the microscope, such tissue as the web of a frog's foot, be irritated to the point of inflammation and watched, it will be seen that the first change is that the blood flows sluggishly in its vessels. The red corpuscles seem to be drawn towards the centre of the stream, while clear serum and white cells are close to the vessel wall. Early in the period of inflammation the white cells begin to migrate from the vessel wall into the tissue space. Cohnheim, the greatest pupil of Virchow, observed this in the cornea of the rabbit's eye. The white cells, or leucocytes, appear to discover fine partitions in the vessel wall and, elongating themselves, push their way through these minute openings and move towards the highest point of inflammatory activity — near the cut edges of the wound.

The unaided eye can discover that, in the opening between the cut skin edges, a sticky fluid is poured out. It consists of blood and fibrin — the scab. For the first few days this forms a weak adhesive agent for the two surfaces, but by the sixth or seventh day it will be found to be quite difficult to pull the edges apart, so firm has this connecting framework become. By the fifteenth or twentieth day a dense connective tissue has formed, which becomes increasingly firmer, so that at the end of three months that particular area is held more firmly together than any other part of the skin. The scar has also contracted and become white, and is in fact less vascular and less elastic than normal skin.

Under the microscope these changes are represented by the regeneration of connective tissue and of epithelial tissue. The fibrin and blood exudate serve as a scaffolding or matrix into which young connective-tissue-cells work their way out from both sides. They subdivide very rapidly, then grow and become mature, and in the course of time knit firmly together into scar tissue. The young connective-tissue-cells are the offspring of connective-tissue-cells in the edges of the wound. What forces cause the sudden production of young cells is unknown. Perhaps it is the function of the white wandering cells of the blood-stream which congregate so closely around the edges of the wound to liberate a hormone which stimulates tissue proliferation of this kind. The epithelial cells in the skin also begin active multiplication and, working out over the fibrin matrix between the two cut edges, form a bridge over the gap, and a smooth skin surface covers over the wound.

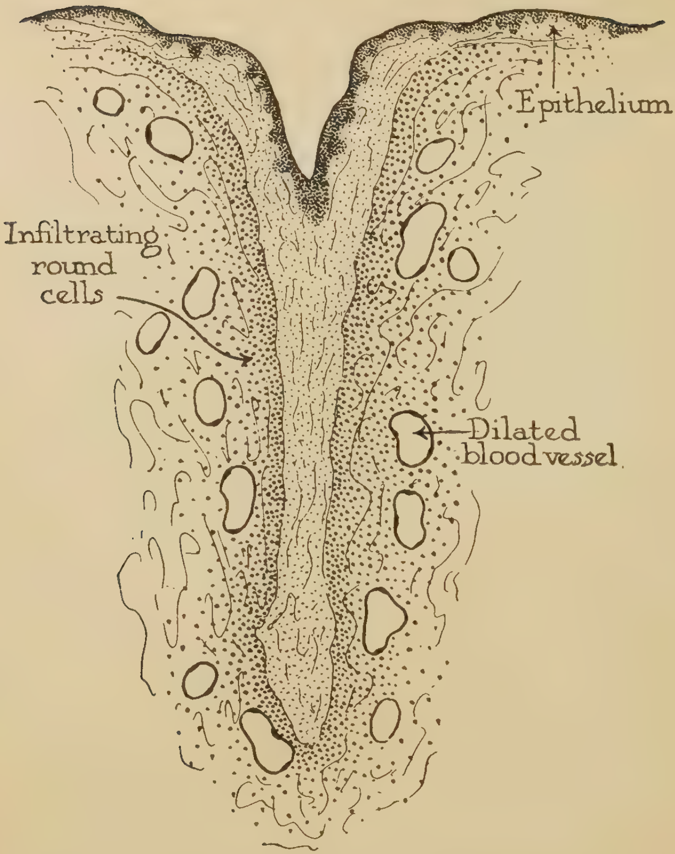

FIGURE 92

Section of a healing wound or cut in the skin. Various stages in the process are shown. Note that in the centre the two cut surfaces have been filled in by fibrous or scar tissue, the fibrous cells being formed by division of previously existing fibrous cells in the edges of the cut. Note that from the dilated blood-vessels has poured an army of blood-cells (round cells) which do the work of cleaning up debris, engulfing bacteria, and some of them perhaps changing into a form of fibrous connective cells. Note that the epithelium of the skin has grown over the surface of the wound, the skin-cells which did this springing from previously existing skin-cells at the cut edges.

All of this complicated process of wound healing has been accomplished by the adjustment and multiplication of cells present in the tissues at the time the wound was made.

There are many features of this complicated process which are mysterious and difficult of explanation. The function of the wandering cells from the blood-stream which station themselves in the tissue spaces is not in all respects clear. One possibility has been mentioned — that they liberate a chemical substance which stimulates regeneration in the fixed-tissue-cells. Being phagocytes capable of engulfing and digesting foreign particles, they probably pick up debris such as dead cells and liquefy them so that they can be absorbed by the capillaries and excreted. When bacteria are present in a wound, the white cells exert their phagocytic activities to engulf and destroy these bacteria. Possibly certain of the wandering cells of the blood are potentially connective-tissue-cells — that is, are young undifferentiated connective-tissue-cells and begin a metaplasia into adult forms.

The purpose of the dilatation of the blood-vessels around the healing area is partly to bring nutrition to the growing regenerating cells, and partly to bring the white cells, which, whatever their function, seem always to be present and necessary. What stimulus causes the immediate enormous dilatation of blood-vessels in a small area just about a clean-cut wound? It is the same about an infected wound, though of even greater intensity. In the case of the infected wound we can conjure up an explanation by saying that it is the irritating effect of the bacteria and their toxins which furnishes the stimulus. But what can we say is the cause in a clean, uninfected wound? Perhaps the dead tissue, and extravasated blood-cells — both inevitable even in the presence of the very minutest trauma or injury — serve as the stimulus. We know that inflammation will occur and wandering cells gather about a sterile foreign body imbedded for experimental purposes in tissue; the area surrounding the foreign body will become entirely liquefied and the foreign body then becomes what is called a sequestrum. Perhaps the same principles apply to the dead tissue in a clean wound. At any rate, the inflammatory reaction is a very delicate adjustment to the body's needs.

The most fascinating of the problems suggested by a study of the healing of a clean wound, however, concern the question of the balance and tension of tissue growth. It becomes of very considerable importance when we examine the circumstances of tumour development, in which this balance is destroyed. We have already had occasion to inquire into it when the subject of the healing of bones came up. Why does the new growth of tissue reach just a certain, just a sufficient, activity and then cease? What causes the sudden impetus to formation of new tissue and what causes

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it to cease, both exactly at the right time and in the right amount? We cannot answer. When we can answer, we shall understand much of the nature of cancer. Of course, in wounds in soft tissue (we found a similar occurrence in healing of broken bone) the process, for reasons which we cannot explain, does not always stop exactly at the right time. There are formed then large redundant scars called *keloids*, which heap up over the surface of the skin like a fungating plant. They are particularly likely to occur in Negroes. They are, in fact, generally classified as tumours. Again in punched-out skin wounds in which the two edges of the skin cannot be approximated, the connective tissues grow from the bottom of the wound, and, before the skin tissues can close over the top of them, bulge out over the level of the skin surface — a condition called proud flesh. The red, bulging young mass of connective tissue is called granulation tissue.

This condition of the healing of a clean incised wound is the simplest form of pathologic process. To examine a slightly more complicated form let us observe a wound which is infected — which means has become contaminated with bacteria. When this occurs, there is a very much larger outpouring of white cells from the blood-stream, for it is these white cells particularly which destroy the bacteria of wound infection. This method of phagocytosis, or engulfment of bacteria by the white cells, has become well known to all laymen through popular literature. The pus which rolls out of an infected wound is simply a liquid collection of leucocytes.

The calling out of the white cells in the presence of infection is an interesting phenomenon. There is not only an increased number of them in the vicinity of the infection, but also an actual increase in their number in the circulation all over the body. Whence do they come? From the bone marrow; from the great reserve stations of leucocytes in the bone marrow and lymph glands. The presence of the bacteria is a call to arms, and like a country engaged in war the reserves marshal and march out. New cells begin to be formed in the bone marrow. So regular is this that in obscure, deep-seated infections such as appendicitis, when some doubt exists as to the nature of the illness, a small vessel remote from the spot of infection, as in the ear lobe or finger, can be opened, and the number of white cells in the circulating blood counted, as a guide to diagnosis. Sometimes they are increased five or six times — there are 30,000 per c.mm. present as against a normal of 5,000 per c.mm. This condition is called leucocytosis.

After the bacteria are destroyed in an infected wound, the wound heals as an uninfected one does.

From a broad biological standpoint the process of healing and inflammation is a beautiful example of the working out of the doctrine of evolution by the method of survival of the fittest. When we ask why there is over-production of leucocytes in inflammation, why the vessels dilate around the edges of a wound, why the growth tension is increased and then diminished, as we did above, we are asking what chemical stimuli are involved and how they are manipulated. But in a larger sense we know that unless these changes occurred in the presence of infection and injury, the individual would die. He would die without progeny, so that the tendency to produce these changes in the body is one that survives, is imbedded in the germ plasm and is transmitted to the descendants of the individuals who possess it.

The nomenclature of inflammation should perhaps be noticed. Inflammation is designated by the suffix *-itis*. The particular part of the body which is inflamed is used as the base of the compound word. Thus inflammation of the appendix is called appendicitis; of the peritoneum, peritonitis; of the kidney, nephritis; of the lining of the heart, endocarditis. A further anatomical designation may be necessary when some special part of an organ is inflamed. Thus otitis media when the middle ear is inflamed; hepatitis dextra when the right lobe of the liver alone is involved. Acute, sub-acute, and chronic refer to stages or degrees of severity of inflammation.

Special forms of inflammation include abscess formation and stone formation. Both are forms of protection against invasion.

An abscess, when fully developed, is usually described by the text-books on surgery as a localized collection of pus. It begins as an entrance of bacteria into a circumscribed area. The commonest location is the skin, the bacteria gaining a foothold in the deeper parts of the skin by entering a hair follicle or sweat-duct. In other instances the bacteria are carried in the blood-stream from a focus of infection, as from the appendix, to the liver (the blood-stream connexion here being direct through the portal vein). Abscess in the throat, or quinsy, results from immediate extension from tonsillitis. The bacteria, as soon as localized, set up inflammatory reaction; being in one spot, they draw an enormous number of leucocytes to that particular area, with the formation of a liquid mass of pus. Around the edges of this mass other leucocytes and young connective-tissue-cells gather as a protective ring — the wall of the abscess. Beyond this wall no bacteria are able to penetrate, and the tissues are healthy. Here it can be pointed out that not only are the inflammatory reactions protective, but even the general bodily symptoms accompanying infection and inflammation have a healing intent. Pain is the outstanding symptom of inflammation. What does it mean? It is increased on movement. A plain warning from nature not to move or bruise the infected part. To handle or massage a boil is to break up the delicate protective wall of leucocytes and connective cells around the abscess and allow the bacteria to escape beyond them and thus cause a widespread or even a general blood-stream infection. Movement, say, of an infected knee will do the same thing. Pain is a good thing for a person to have when sick.

An abscess, if not relieved by surgery, by incision and drainage (*Ubi pus, ubi evacuo* — "wherever there is pus, there must you evacuate" — being one of the oldest of surgical rules), will usually burrow its way to the outside and open spontaneously. Sometimes it becomes encysted by thick walls of connective tissue, all the bacteria inside are killed off and it remains, even for years, as a sterile collection of pus. The burrowing of pus may assume fantastic forms. From a tubercular abscess of the spine it often burrows down along the spinal muscles and comes out on the skin of the thigh — a psoas (the name of the spinal muscle) abscess. From an appendix abscess it may burrow upwards and localize underneath the diaphragm — a sub-phrenic abscess. From an abscess of the pleural cavity following pneumonia it may, if undetected and unopened, work its way through the lung into a bronchus and be discharged as sputum.

When infection occurs in one of the open sacs of the body, ordinarily filled with fluid of some kind, such as the gall-bladder, the pelvis of the kidney, or the bladder, the bacteria are first surrounded by mucus and leucocytes secreted and thrown off from the epithelial cells of the lining of the wall of the sac. Around this nucleus the salts dissolved in the fluid naturally present are deposited, forming a stone. This process has already been described, but it is worth pointing out that from the standpoint of our present discussion even so distinctly pathologic a condition as a stone is in reality a protective device of the body, and a very efficient one, as the stony deposits very effectually limit the activity of the invading bacteria.

CHAPTER III

THE INFECTIOUS DISEASES AND IMMUNITY

In the preceding chapter we considered localized infections; we dwelt particularly on the interplay between the injury or infection and the body's reaction — its method of defence. Now we may carry the same view-point a step further and examine the interplay of body-reactions and invading disease in those infections which are general — the infectious diseases. In these the germs enter the blood-stream and produce distinct forms of poisoning, each of which initiates a particular kind of reaction in the body.

It is not my intention to describe in any detail the symptoms of each of the infections. I am concerned here with establishing principles.

All general infections, such as typhoid fever, diphtheria, pneumonia, smallpox, measles, meningitis, tuberculosis, influenza, or Asiatic cholera, do one of two things or both. Either, as in the case of typhoid, they get into the general blood-stream or lymph-stream, the bacteria multiplying and spreading all over the body, or, as in the case of diphtheria, they localize in one place, and elaborate a toxin or poison which is absorbed and carried all through the body, or, as in the case of pneumonia, they do both.

In some infections, a good example of which is tuberculosis, the bacilli locate in one spot, cause a good deal of tissue destruction there, elaborate at the same time a mild toxin, and then become so numerous that some are caught up in the blood- or lymph-stream and locate in another part of the body, to renew activity there. This is a variant type of localized activity with toxæmia, combined with blood-stream infection, the latter being sporadic.

Whenever a general infection occurs, the body must overcome it or be overcome. The mechanisms of defence are numerous. Partly they are local, much like the local inflammatory reaction of healing which we have just studied. Thus the spots of measles are probably local inflammatory skin-reactions around the germs of measles located in the skin. The pustules of smallpox are likewise small local abscesses. The reaction of the throat to the invasion of diphtheria bacilli with membrane formation is a local inflammatory reaction at the site of invasion of the disease. The formation of the exudate in the air spaces of the lung in pneumonia, engulfing and finally destroying the pneumococci, is an example of special inflammatory reaction adapted to the structure of the organ involved.

But besides these local reactions there is a general response on the part of the entire body. One form of this is the disturbance of heat regulation called fever. The symptom of fever is in itself distinctly helpful and protective. In the first place, it has been found that some bacteria show great activity at ordinary body temperature, but begin to become sluggish in growth and power of multiplication at the temperature of 102. One of the worst signs in some infections is a low temperature. It shows the body is not reacting vigorously to the disease. But the greatest value of the state of fever has been experimentally demonstrated by Rolly and Meltzer. They showed that the production of immune bodies or antidotes to the poison of bacteria were produced very much more rapidly in an animal whose body was experimentally raised in temperature than in an animal whose body was normal or lower in temperature. Particularly this applied to agglutinins and bacteriolysins, substances formed in the body which are poisonous to bacteria, in the case of agglutinins rendering them inert, and in the case of bacteriolysins actually dissolving them.

It is rather amusing to contrast this conception of fever with the custom, now happily nearly extinct, of attempting to "break the fever" with drugs and such other methods as sweating and bathing. Nature has carefully elaborated fever, has built up through thousands of years this beautifully adapted method for the protection of the body against the great army of microscopic invaders always lying in wait for it, and in the thought of an only recently bygone age the only significance of its appearance was as a sign to thrust rude hands into nature's plans and change her course. It was the fatal mistake of regarding a symptom as a detriment. Symptoms are often merely protective devices. We have glanced at the protective value of *pain* in inflammation in the last chapter. Vomiting is often the throwing off of a noxious substance from the stomach — in such a condition as appendicitis it may occur for the purpose of emptying the stomach so that no peristaltic waves are initiated in the small intestine — waves which would spread the focus of infection or rupture the abscessed appendix. Cough is a protective symptom — an ejection of septic material from the lungs and bronchi. And we must regard fever in the same way, though its mechanisms are subtler than those of the other symptoms mentioned.

The devices employed by the infected body to raise its own temperature are interesting. Under normal conditions heat regulation is very delicately adjusted — the increased amount of heat produced by muscular action being dissipated by dilatation of blood-vessels on the surface of the skin, and by the secretion of perspiration, which in drying causes a lowering of temperature. In infection these heat-dissipating mechanisms are in abeyance. The infected individual feels chilly — he wants to get into a hotter and hotter room. The onset of infection is often heralded by a chill. Dr. MacCallum has an instructive description of a chill. "The superficial vessels of the skin are contracted so that little blood is carried to that radiating surface. The skin is pale or livid. The sweat glands stop secreting . . . the smooth muscles in the skin contract and pull into goose-flesh; the person feels cold, cowers together, covers himself heavily with blankets, and shivers violently, thus turning stored-up energy into heat. Every available mechanism is brought into play to stop the dissipation of heat and to warm up the body, and in spite of the sensation of cold the temperature of the interior is at its highest during the chill."

The most effective of the devices used by the body to combat infection is the production of immunity. The gross manifestations of immunity are easy to observe and have been matters of record for a long time. The underlying fact is that one attack of an infectious disease will protect against subsequent exposure. To a large extent this immunity is specific — i.e., an attack of measles will protect only against measles, not against typhoid fever or diphtheria. The immunity conferred by an attack of a particular disease lasts a variable length of time, in some instances for life;

individuals seem to vary, however, in their ability to hold immunity, and some will have the same disease two or three times during their lifetime. In certain diseases — for instance, pneumonia, streptococcic infection, and acute articular rheumatism — the period of immunity is very short, and there are even students who believe that an attack confers a hyper-susceptibility rather than an immunity.

To these gross facts, which have been part of the common lore of mankind since time immemorial, scientific medicine has supplied the most elaborate and intricately proved set of explanations. It is able to show how in some diseases the mechanics of cure and immunity production is of a certain kind, and in other diseases is of a different kind. It is able in certain diseases to produce the immune substances. It is even able to produce in a human body which has never had one of these diseases exactly the same kind of immunity, without harm or danger, as it would have had if it had gone through the vicissitudes of the disease itself. If these things had not grown stale with familiarity, they would savour to us of magic. They constitute the greatest triumph of scientific medicine. They constitute, indeed, one of the greatest of the practical victories of science in the ages.

The first knowledge of them came with vaccination against smallpox. The story is worth recalling because the growth of that knowledge was slow and tortuous. Edward Jenner, whose name is always associated with the introduction of vaccination, does not deserve all the credit that he usually receives. The way was well prepared for him. What Jenner introduced was vaccination with cow-pox as a preventive of smallpox. But all during the eighteenth century preceding his work medical thought was busily engaged with the practice of inoculation, which is the introduction under the skin of pus from actual human smallpox pustule. Both inoculation and vaccination produced the same result — they caused a mild form of smallpox which created sufficient immunity to protect against subsequent exposure.

The minds of men in the eighteenth century were thoroughly prepared by the knowledge of inoculation for the possibility of preventing smallpox. They were even better prepared by first-hand experience with a knowledge of the horror of the disease. The incidence of the disease in the eighteenth century was almost universal, its mortality was frightful. In the city of London from 1707 to 1722 there was only one year when less than one thousand people died of smallpox, and in that year, 1711, 915 died. In 1719 over 3000 died. The total mortality of London during those years was about 20,000. The effectiveness of vaccination is easily demonstrated, even if the demonstration is largely statistical. London was in 1719 a city of about half a million population. In what city of that size in the United States to-day do even ten people a year die of smallpox? In all England in 1900 seven people died of it; in 1903 a very high mortality of 760 was reached.

The introduction of the practice of inoculation into Europe is ascribed to the interest of Lady Mary Wortley Montagu, who was the wife of the English ambassador to Turkey in 1717. The event was so significant for the health of mankind that it may be presented in the very words of that vivacious correspondent, of whom Pope wrote:

> In beauty or wit
> No mortal as yet
> To question your empire has dared,
> But men of discerning
> Have thought that in learning
> To yield to a lady was hard.

"Apropos of distempers," she writes, to Mrs. S. C. on the first of April, 1717, "I am going to tell you a thing that I am sure will make you wish yourself here. The smallpox, so fatal and so general amongst us, is here entirely harmless by the invention of *ingrafting*, which is the term they give it. There is a set of old women who make it their business to perform the operation every autumn, in the month of September, when the great heat is abated. People send to one another to know if any of their family has a mind to have the smallpox: they make parties for this purpose, and when they are met (commonly fifteen or sixteen together), the old woman comes, with a nutshell of the matter of the best sort of smallpox, and asks what veins you please to have opened. She immediately rips open that you offer to her with a large needle (which gives you no more pain than a common scratch) and puts into the vein as much venom as can be upon the head of her needle. . . . [The eighth day] the fever begins to seize them. . . . They have rarely above twenty or thirty pustules in their faces, which never mark. . . . The French ambassador says pleasantly that they take the smallpox here as they take the waters in other countries."

The practice of inoculation had many famous exponents during the half-century following. Dr. Maitland was the immediate English pupil of Lady Mary. The Princess Caroline ("There never was a clever woman who was not a quack," some scoffer observed) persuaded George I to pardon six condemned criminals who would submit to inoculation for purposes of experiment, and accordingly Maitland in 1721 inoculated Mary North, Anne Tompion, Elizabeth Harrison, John Canthery, John Alcock, and Richard Evans of Newgate, all of whom thus escaped hanging and after a mild dose of smallpox were free to pursue their customary vocations and avocations. In France Louis XVI was inoculated in 1774, and Marie Antoinette's milliner, Mlle. Rose Bertin, in honour of the occasion designed a special head-dress, which was shaped like a smallpox pustule; the royal patient was protected from smallpox, but he was not so successful as the English experimental animals from Newgate in escaping judicial extinction.

Royalty is always a barometer of the popularity of a custom. The fact that we have so many accounts of the practice of inoculation in royal households indicates with what fervour and interest the whole population of Europe took up this hope of salvation from the horror of the disease smallpox.

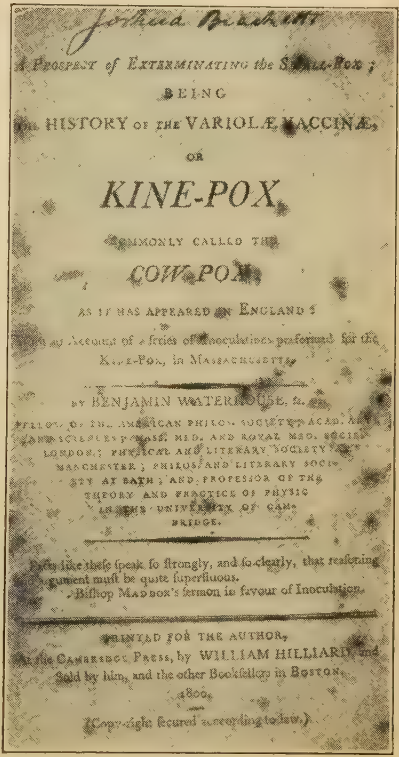
The most famous of eighteenth-century inoculators was Thomas, afterwards Baron Dimsdale. He was a copious, not to say inexhaustible, writer. He had a taste for dialectic and joined issue at the slightest provocation with every opponent of the procedure. He was invited to visit Russia by Catherine II and introduce inoculation into that country. I have before me the memoirs which he produced as the result of that adventure. That he was asked to make the journey into that Russia which was then so sensitive to the new fashions in Europe is additional evidence for my belief that inoculation was widely practised and prepared the way for the acceptance of Jenner's doctrine. In his book the Baron tells us much of the condition of Russia at the time. The fear of inoculation was very real: it had been exaggerated by the wildest and most fantastic stories. The peasants fled from the Baron's presence as from a pestilence. A company of the Imperial

Guard accompanied him to a house where by Her Majesty's command the children of the household were to be inoculated. He tells us of the poor mother cowering in the corner of the room, pathetically attempting to hide her youngest, a little boy of three. Finally the terror inspired by the Empress's command was so great that she herself decided to set the example. She ordered Dr. Dimsdale to inoculate herself, her lover Gregory Orlov, and her son, the Grand Duke Paul, the heir apparent. The doctor has a spicy and vivid account of the court and the people. With true British phlegm he describes the person and functions of the Empress; it appears that the imperial bowels possessed so much *lèse-majesté* as to be very costive. The inoculation of all three persons was quite successful. They exposed themselves to smallpox and did not take it. After their example many members of the court submitted to the operation, and the physicians of St. Petersburg were instructed.

Several years later, a humorous sequel occurred. Catherine had installed a new lover in the place of Gregory Orlov — a handsome and virile youth named Vassilchikov. Orlov was in Moscow when he heard the news — intelligence which was naturally very disturbing to him. He started to ride to St. Petersburg to investigate. But Catherine, who had no mind for interruptions by former lovers in the first heat of her new passion, had Orlov stopped by a military guard and incarcerated in his own palace at Gatchina, because, as she considerately explained, she was afraid he would catch smallpox, which was then prevalent in St. Petersburg. Years before, of course, the announcement had gone out that, at considerable expense to the Russian people, the person of Gregory Orlov had been rendered immune to the ravages of the smallpox. Whether in her crimson chamber Her Imperial Highness had forgotten that far-off fact, or whether, as is the habit of empresses, it was merely convenient not to remember, has never been divulged.

The general idea, then, that smallpox could be prevented was already prevalent when Jenner began to think upon the problem. There was current a good deal of gossip that it could be prevented by acquiring the much milder disease which occurred in the horse and cow. Milkmaids who had cuts on their hands and then milked cows with cow-pox pocks on the udder were occasionally inoculated and it was generally known that they were immune to smallpox.

The Duchess of Cleveland, the mistress of Charles II, replied once to the remark that if she got the smallpox, it would spoil her beauty, and her occupation would be gone, by saying that she had a disease which protected her against smallpox. A dairymaid told Jenner that she "could not take the smallpox as she had had the cow-pox." In 1796 Jenner put the question to the proof of experiment. He took matter from the hand of a dairymaid, Sarah Nelmes, and inoculated a boy of eight, James Phipps. The names of these early sacrificers in the temple of science have always a pathetic and ironic interest. How terrified the little fellow must have been! Do you remember that famous bronze statue by Monteverde of "Jenner Inoculating His First Patient"? It used to adorn the table in doctors' waiting-rooms all through the spacious days of Grover Cleveland. The little patient's face is contorted with sheer dread. Why shouldn't it have been? He was, just as much as Columbus, sailing out on a new, a dark, and an uncharted sea. He was having the pus, the matter, the poison of a disease put into him. Nobody on earth knew exactly what the outcome would be. What ever became of them — him and Sarah Nelmes? Doubtless they lived out their placid, uninspired existences in the dairies of Gloucestershire. We know of them merely because once they touched a man of genius. Only for one brief moment they are illuminated on the stage of history — their names, their ages, their sores all pitilessly exposed — and then the void and black night swallows them again.



A Prospect of Exterminating the Small-Pox;
BEING
the HISTORY of the VARIOLÆ VACCINÆ,
OR
KINE-POX,
COMMONLY CALLED THE
COW-POX;
AS IT HAS APPEARED IN ENGLAND:
with an Account of a ſeries of Inoculations performed for the
Kine-Pox, in Massachusetts.

BY BENJAMIN WATERHOUSE, &c.
FELLOW OF THE AMERICAN PHILOS. SOCIETY; ACAD. ARTS
AND SCIENCES MASS. MED. AND ROYAL MED. SOCIETY
LONDON; PHYSICAL AND LITERARY SOCIETY
MANCHESTER; PHILOS. AND LITERARY SOCI-
ETY AT BATH; AND PROFESSOR OF THE
THEORY AND PRACTICE OF PHYSIC
IN THE UNIVERSITY OF CAM-
BRIDGE.

Facts like theſe ſpeak ſo ſtrongly, and ſo clearly, that reaſoning argument muſt be quite ſuperfluous.
Biſhop Maddox's ſermon in favour of Inoculation.

PRINTED FOR THE AUTHOR,
At the Cambridge Press, by WILLIAM HILLIARD, and
Sold by him, and the other Bookſellers in Boston.
1800.
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FIGURE 93

Title page of Benjamin Waterhouse's account of his experiments with vaccination, the first made in America.

James Phipps did not, at any rate, suffer any living horror.

He had a perfectly normal vaccination pustule, such as all of you who read these pages, I hope have had. But the final proof of the effectiveness of this pustule in preventing smallpox was still to be made. Jenner had planned it. The boy must be exposed to an actual case of smallpox.

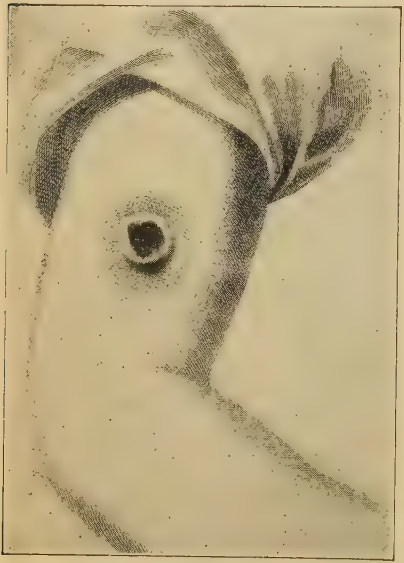

FIGURE 94

Representation of a vaccination pustule from Jenner's original account of vaccination.

The crucial test was made on him three months after his vaccination, when matter from a smallpox pustule was injected into his skin. No disease developed. This feature is often, in fact usually, forgotten when the efficacy of vaccination is discussed — that in all the early cases the effectiveness of the vaccination was tested by subsequent exposure to, or inoculation with, actual smallpox. All of the earlier cases reported by Jenner in the original *Inquiry* (1798) were tested in this way. Benjamin Waterhouse, the first American vaccinator, in 1800 vaccinated seven of his children. He seems to have had plenty of them — fifteen I have heard. Upon what basis — age, sex, intellectual acuity, or personal charm — the selection of the seven was made is not divulged. Later they were marched to the pest-house and exposed to smallpox. None of them took it. In 1802 Waterhouse vaccinated nineteen boys, later introducing smallpox matter under the skin of twelve of them. None of the twelve developed smallpox. Two unvaccinated boys were inoculated at the same time with the smallpox matter; both developed smallpox. William Osler called this "one of the most crucial experiments in the history of vaccination."

On account of the malignancy of the disease in the eighteenth century, and because the popular mind was prepared for it by the practice of inoculation, vaccination was accepted more promptly and more generally than nearly any other medical innovation of equal danger and strangeness. By 1805 so hard-headed a realist as Napoleon was convinced and ordered, so far as was possible with the supply of lymph, universal vaccination in his armies. The clergy were on this occasion divided, on a scientific topic. Some believed it was a plain interference with the purposes of Almighty God. Others, such as the Bishop of Worcester, preached sermons answering objections and recommending the practice to all his communicants. There was a great deal of perfectly natural fear of vaccination, however, in those days. The most astounding evidences of human credulity were the reports of human beings assuming cow-like characters after vaccination. I reproduce a contemporary cartoon which illustrates this belief (Figure 95). It was, remember, produced in all seriousness as an attack on the practice.

There was a long wait before another method of artificial immunization against a human disease was known. In 1885 Pasteur inoculated the first patient with antirabic vaccine prepared from the spinal cord of a rabbit. Because of its frequency and deadliness, the conquest of diphtheria is perhaps the most notable achievement in immunology since Jenner. After Loeffler's discovery of the diphtheria bacillus, Roux and Yersin made the important demonstration that the symptoms of the disease are not due to the wide distribution of the bacillus in the body, but that the bacilli remain in one spot and elaborate a toxin which is absorbed into the blood. In 1892 von Behring showed that the horse was naturally immune to diphtheria and that the immunity was due to the rapid production in the horse's body, after inoculation with living diphtheria bacilli, of an antidote or antitoxin. This antitoxin is in solution in the blood-serum of the horse and, when it is injected into a patient with diphtheria, neutralizes the poison of the disease. Since 1892 diphtheria mortality — that is, the number of people who die after acquiring the disease — has dropped from 50% to less than 10%. In those to whom adequate doses of antitoxin are given early it is less than 2%.

The facts gathered from the work on diphtheria antitoxin illuminated certain aspects of immunity mechanism. Diphtheria antitoxin will protect against diphtheria, but not against any other infectious disease. Therefore the antitoxin will *fit* the one toxin and no other. From this Ehrlich advanced his "side-chain"

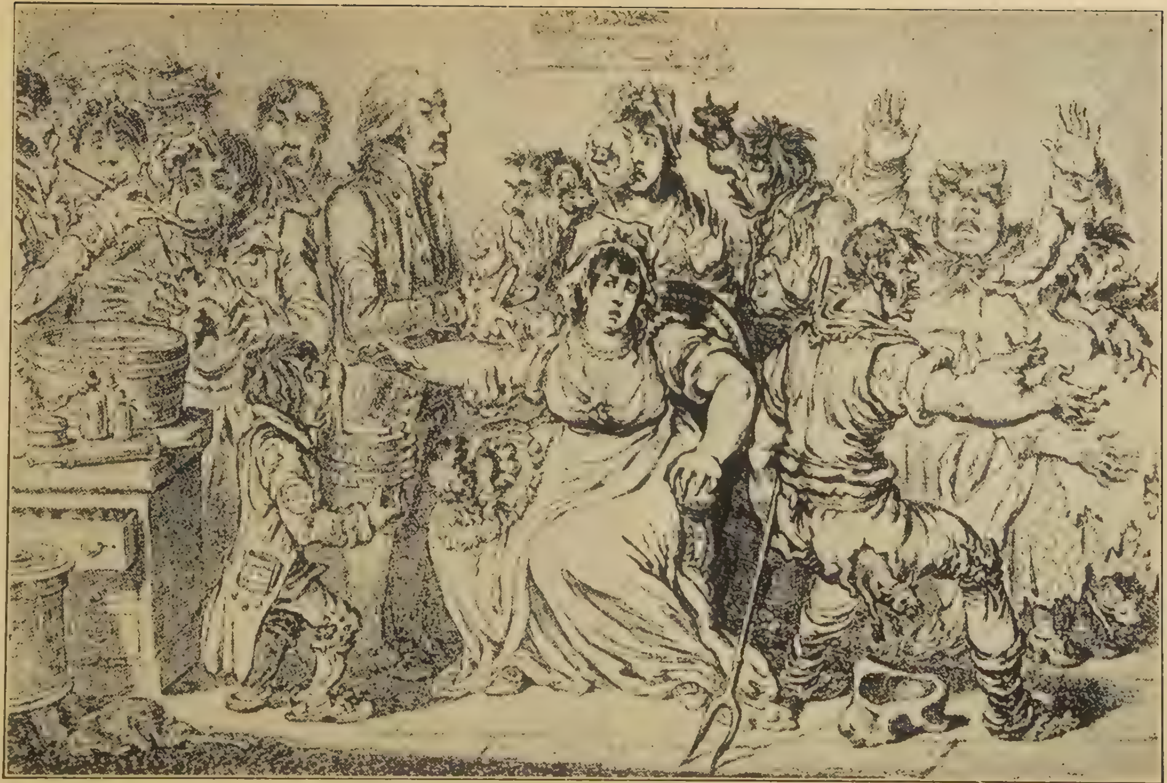

Figure 95

A contemporary cartoon, used as an argument against vaccination, 1802. The artist believed that cows' heads and horns would grow out of some part of the body of those vaccinated.

theory of the nature of immunity. The production of immune bodies takes place in all the cells of the body. It is possible that certain organs — the spleen, the liver, and the thyroid — are particularly active in their elaboration, but no organ or set of cells, so far as we know, has an exclusive function of this sort. Ehrlich supposed that when the toxin or the bacterium of an infectious disease comes in contact with a body-cell, the cell is stimulated to produce a certain kind of chemical substance which will neutralize the poison or kill the bacterium. These chemical substances are specific — fit only the bacterium or toxin involved. When once started, they are produced in very great quantities and the cell is sensitized to produce them all through the life of the individual. Whenever the same bacterium for which an antidote has once been produced by the body-cells again enters the body, the cells which have already learned the habit of producing antidotes are immediately activated to pour out enough antibodies to overcome it.

Typhoid fever is another disease which is completely conquered. The hypodermic injection of large numbers — 1,000,000,000 — of dead typhoid bacilli in three successive doses confers an artificial immunity which lasts for from three to seven years. Its efficiency was demonstrated in the late war, where, after universal typhoid immunization, typhoid fever was a rare disease — one case in about every 4,000 men as against one case to every 7 men in the Spanish-American war. The mechanism of typhoid immunity is somewhat different from that of diphtheria. The typhoid bacillus is mobile — if put under the microscope, in a drop of broth, the bacilli will be seen moving about very rapidly. Now, if a drop of the serum of a typhoid patient be added to this, in the course of an hour the bacilli will largely have lost their motion, and be agglutinated in clumps. From this the idea is gathered that the blood of the typhoid patient develops certain substances which destroy the typhoid bacilli by stopping their activity and clumping them together so that the wandering cells of the blood can engulf them. These substances are called agglutinins.

Another mechanism seen in other infections is the elaboration of bacteriolysins, which actually dissolve the bacteria involved.

The diseases besides smallpox, diphtheria, typhoid fever, and rabies for which we can produce an artificial immunity are tetanus, or lock-jaw, for which a preventive serum is available, meningitis of the epidemic form, colon-bacillus infections, and the latest addition — scarlet fever.

The final step in the conquest of diphtheria was accomplished when a mixture of toxin and antitoxin was shown to be a preventive. For diphtheria our data are complete: (1) we know the cause, so the diagnosis can be made promptly and certainly; it does not depend upon the guesswork of symptoms; (2) we have a curative specific serum, to be used after the disease is acquired; (3) we can determine, by the Schick test, which healthy individuals are susceptible, which are immune from it; (4) we can make the susceptible individuals immune by a preventive serum. In every infectious disease the hope of organized medicine is bent towards the same goal.

CHAPTER IV

HYPERSENSITIVENESS

Bacteria are, of course, not the only external agents which cause trouble in the body. There are chemical agents, such as poisons, which produce changes and death. Certain poisons have a very definite affinity for certain cells in the body. Thus mercury picks out the cells lining the kidney tubules from all other cells in the body, forms a union with them, and, as is the case with most unions, destroys them. Strychnine affects particularly the central nervous system. Arsenic and phosphorus attack especially the cells of the liver.

Physical forces, such as heat resulting in burns and sunstroke, cause disease.

A cause of disease which has only recently been elaborated, but which is found to have many manifestations, consists in a hypersensitiveness on the part of certain individuals to the presence of substances that are harmless to others. I bring it up partly because it is a real cause of disease which cannot be classified in any other category, partly on account of its novelty, and partly because it seems to display a perversion, degenerative and not protective, of processes which are akin to the processes of immunity. Hitherto we have been dealing with protective reactions of the body. Here is a reaction which is harmful and not helpful. In what follows we shall study largely degenerative and harmful changes in the body. It may be valuable to examine one condition which, while it is harmful, is not usually fatal.

The first announcement of this singular group of phenomena died still-born. In 1867 Henry Hyde Salter published a book in which he described his own case of asthma — "The cause of this affection," he wrote, "is the proximity of the common domestic cat. . . . I cannot recollect at what time I first became subject to the cat asthma, but I believe the liability has existed from the earliest period of life. I believe some asthma would present itself if I were sitting by the fire and the cat sleeping on the hearth-rug; but the effect is much greater when the cat is at a distance of two feet, or still closer; it is still further increased by the raising of the fur and moving and rubbing about, as is the habit of cats when they are pleased, also by stroking their fur; but most of all when they are in the lap just under the face. The influence seems to be stronger in kittens from two months old and upwards than in full-grown cats. . . . With respect to the symptoms, I have only to say that they resemble those of hay-fever. . . . The asthmatic spasm is immediate and violent, accompanied with sneezing and a burning and watery condition of the eyes."

These observations, whether they were read or not, went practically unnoticed until the accumulation of similar data during the last few years caused them to be unearthed. The number of people sensitive to some animal emanation is legion. The largest group of them are sensitive to horsehair. Most of them have asthma when near a horse. Some few develop hives or other skin eruptions. Some have running noses and weeping eyes. Dogs, cattle, chicken feathers, and duck feathers all cause certain people discomfort of this kind.

Animal emanations are not the only things which provoke these responses. The most frequent, of course, is pollen from plants causing hay-fever. The scientific basis of our knowledge of hay-fever was laid down by Blackley, who published two books, one in 1873 and one in 1880. Blackley himself had hay-fever and came to the belief that the pollen grains from grasses caused it. He collected some of their pollen dust, saved it, and snuffed some into his nose in the middle of winter, producing a typical attack of hay-fever. He also exposed gelatine plates throughout the summer and found what pollens predominated in the air in the hay-fever times.

Foods were found to be the cause of hypersensitive reactions in children. They caused diarrhœas and especially skin eruptions such as hives. Many individuals are affected by a particular food, which is entirely innocuous to other people, and which gives them hives or some other form of skin eruption or produces asthma.

For heaven knows how long, the individuals who possessed these food idiosyncrasies were regarded by the profession, and especially by their relatives, as neurotics. I have a patient who is sensitive to Brazil-nuts. The tiniest bite into a Brazil-nut will give him a violent attack of asthma. To chew and swallow half a nut causes him to have asthma and a violent outbreak of hives. When he was a little fellow in England, he discovered this peculiarity about himself, but he did not persuade his solid-minded British grandparents. They determined he was exhibiting nonsense and decided to get it out of his system. So they made the poor little chap eat Brazil-nuts until he nearly suffocated with asthma, turned blue, and the services of the family practitioner were needed. They did not repeat their experimentation, but the patient says he does not believe they were ever fully convinced: he was always the least favoured of their grandchildren, and they sniffed contemptuously whenever the subject of Brazil-nuts came up. Of course, now he never eats a Brazil-nut if he knows it. But occasionally a box of candy will contain a few Brazil-nuts artfully disguised in a film of chocolate. If he is not on the alert, he may bite into one of these. He immediately retires and spits it out, but just the amount of juice he gets on his teeth invariably causes an attack of asthma.

Some light was thrown on all these phenomena when, about 1905, two Austrian pediatricians and two American experimental pathologists demonstrated the occurrence of what has since been called anaphylaxis. They found that if they injected some horse-serum into a guinea-pig, no symptoms were produced, but after an interval of 8 to 12 days a second injection of even a very small amount of horse-serum caused the animal to have serious symptoms. The breathing was difficult, resembling an attack of asthma, and the animal usually died in the attack. When autopsied, the lungs were seen to be greatly distended and the bronchioles going into the terminal air sacs in a state of spasm. No good explanation of the mechanism of this phenomenon has ever been advanced. The first injection of horse-serum is said to put the animal in a state of sensitiveness, the second injection in some way to release poisonous chemical products which initiate the asthma.

A great advance in the study of cases of human hypersensitiveness was made when it was found that the skin of a sensitive individual will react with a swelling and a wheal when some of the substance to which he is sensitive is introduced, either in a scratch in the skin or by a fine hypodermic needle, *into* the true skin (not beneath it). My friend who is sensitive to Brazil-nuts will, if I introduce into his skin a very infinitesimal amount of Brazil-nut juice in salt solution, respond in a very few minutes with a large white swelling at the site of the injection. The introduction of a solution of peanut, or walnut, or almond, will not produce any response. The reaction is quite specific. Thus we are able to make a diagnosis of the cause of an obscure asthma or skin eruption in many instances by having solutions of offending foods, animal dandruff, pollens, and other substances prepared and injecting them into the skin of patients until one gives a reaction. The procedure is neither so painful nor so harmful as it may sound.

Curious stories are told of some of these cases. Thus, a woman had occasional attacks of light asthma. They were not seasonal; i.e., could not be associated with the pollination of any plant, as in hay-fever asthma. After many trials she arrived at the peculiar conclusion that her attacks came on every time she had her watch cleaned. Jewellers use box-wood dust to clean gold; this woman gave a violent skin-reaction to a solution of box-wood dust. Her watch remains dirty, but she has no asthma and she lives happy ever after.

A dermatologist friend of mine told me of a patient who consulted him at the office for a widespread and annoying skin eruption. He treated her for some time without success. Finally she asked if he would advise a trip to a near-by watering-resort, which he did. She called him up from the springs three days later to say that the dermatitis was gone. She stayed on another week, however, and then came home. The next day she was back at the office with a fresh attack of dermatitis. She returned to the springs and the dermatitis disappeared. She returned home and it reappeared. By this time my dermatological friend decided to go out to the patient's house. He found her in a room with primroses in boxes on every window ledge. He opened the windows and pitched the boxes out, and her primrose dermatitis rapidly cleared up.

The diseases caused by hypersensitization reactions have already been mentioned — asthma, hay-fever, hives, dermatitis, and perhaps some gastro-intestinal upsets. There is, I think, no convincing proof that any other symptoms are produced in this way. Not all cases of asthma nor all cases of hives are of this character. Many of them baffle all attempts to discover an offending substance to which the patient is sensitive.

Hay-fever is a particularly annoying scourge in this country, far worse than in Europe. It occurs during, chiefly, two seasons, the spring and the late summer or fall. These used to be assigned respectively to the roses — "rose-fever" — and the golden-rod. As a matter of fact, the spring type is almost invariably caused by the pollen of the grasses — timothy, orchard grass, and blue grass — and the fall type by some member of the ragweed family — ragweed, horseweed, cocklebur, or sage. Pollination — that is, the spread of the male element of plant fertilization from one plant to another — is accomplished in general in two ways. One is by insect carriers; plants which pollinate by insect cross-fertilization have developed conspicuous flowers to attract the insects. The other method, wind distribution of pollen, does not need the development of conspicuous flowers, but depends upon a heavy growth of light pollen grains, which, when they are ripe, are cast into the air in great profusion. Naturally the cause of hay-fever will be wind-borne pollen. Naturally too, at first the flowers which bloomed lavishly at the time the symptoms of hay-fever developed were noticed and implicated by the victims. Of course, a shaggy flower like the golden-rod will catch a great many ragweed pollen grains and these will again be shaken from it when the victim is in proximity to it. But the actual pollen grains of flowering plants are usually sticky and heavy and not fit for distribution by wind.

The ragweeds grow with ferocious abundance from late June to October in the states from just beyond the Atlantic seaboard to the Rockies and from the southern border of the Great Lakes nearly to the Gulf. That area is the worst for a hay-feverite. I find that most sufferers do not know the ragweed when they see it, though it is a very conspicuous plant.

Prevention of hay-fever is practised by giving a series of injections of increasing strengths of pollen extracts. It is only fairly successful, about 50% of those so treated being relieved. The amount of trouble involved in taking the vaccines, over a period of twelve to fifteen weeks before the expected attack, almost makes the treatment more than it is worth.

A better method of attack would be for all the hay-fever victims in a community to organize and contribute a small sum apiece to employ gangs of men to cut down ragweed and horseweed in their territory. I am convinced that if a large number of such associations were formed, the severity of the disease would be decreased seventy-five per cent.

CHAPTER V

SECONDARY AND DEGENERATIVE TISSUE CHANGES

An inflammation, an infection with bacteria, a burn or an escharosis with acid will, of course, cause destruction of tissue, more or less widespread. The process of healing will not entirely replace this destroyed tissue. We have heretofore considered inflammation in spots where the destruction of some tissue will not be seriously felt by the whole organism — in the skin, for example.

But inflammation or destruction of tissue may occur in a place where the tissue involved is of vital consequence to the functioning of the body and where regeneration does not take place either at all or with any completeness. For instance, some poison or destructive agent may enter the body which has an affinity for the islets of Langerhans in the pancreas. This will result in diabetes. The healing forces of the body may fill in the spaces where the cells of the islets were, but the replacement will be with scar-tissue and that will not restore the vital function of the islets. A good many cells of lung-tissue can be destroyed without interfering with the smooth functioning of the body: there is always more lung-tissue than is needed; the destroyed part may be filled in with scar-tissue and the rest of the lungs carry on. Liver-cells may be destroyed in large quantity; yet the regenerative power of the liver parenchyma is such that it can replace these very rapidly, so rapidly that no break can be detected in the smooth functioning of the organ. But the cells of the kidney, the cells of the nervous system, of the heart-muscle, of the thyroid gland cannot be destroyed without serious consequences.

This clearly brings us to the most serious aspect of disease we have yet encountered. External or, as we shall see, sometimes internal, forces may bring about destruction of tissue for which the protective powers of the body are inadequate to compensate.

As in all these reactions, there are various degrees of adequacy of body response. The body always tries to save itself from destruction. Sometimes even though blindly, as in inflammatory reaction and wound healing, it does something very ingeniously and better than any intelligence could do for it. At other times, equally blindly, it adds to the destruction. But always, within the limits of its powers, it is helping as best it can.

Hypertrophy is a most helpful tissue response to injury. It means, of course, enlargement and may be the sum of the enlargement of a number of individual cells, or both individual cell enlargement and increase in the number of cells. The latter condition is distinguished by the term "hyperplasia."

Muscle-tissue is particularly likely to be the seat of hypertrophy, and muscles hypertrophy in response to a mechanical defect, such as an obstruction. Thus when an infection has lighted on the valves of the heart and a mechanical difficulty results — leaking valve or obstructed valve — the heart-muscle enlarges because there is more work to do. This is plainly a helpful reaction and indeed is technically called compensation. In the same way the muscle of the bladder hypertrophies when there is an obstruction at the outlet of the bladder, whatever the cause — prostatic obstruction, stricture of the urethra following gonorrhœa, or abscess of the urethra. The muscle of the stomach will likewise hypertrophy if an ulcer has formed at the pylorus (or stomach outlet) and in healing has caused a stricture with an obstruction of the outlet of the stomach. The stomach-muscle has to become stronger — i.e., to hypertrophy — in order to pass food out of the stomach past the mechanical obstruction.

A somewhat different type of hypertrophy occurs when one of a pair of organs, such as the kidneys, is destroyed and the other (kidney) enlarges to do the work of both. Many, if not all, of the enlargements of the thyroid are of this character. Hypertrophy of the prostate is the name given to a change in the prostate which we do not fully understand. The enlargement of the prostate occurs in old men, after their sexual powers are in abeyance. The enlargement is caused usually by an overgrowth of glandular tissue, sometimes of fibrous or smooth muscle-tissue, and its true nature seems to be of the character of a tumour, a change occurring in an organ in a state of degeneration like, to make an analogy in the female, the adenomyomas of the uterus after the menopause.

The most frequent and potent cause of the degeneration of organs for which little if any compensation is attempted by the body is the change which occurs in all the blood-vessels of the body, particularly the arteries, as a normal process of growing old. There are many theories among my colleagues as to the cause for this change. My own views, which I have already expressed in the section on high blood-pressure, are purely fatalistic — I do not believe there is any explanation in the realm of pure biology adequate to cover the ground. All I can say is that the world seems to be arranged so that various animals have their own span of life. That after they have passed their reproductive period, nature takes care to shove them from the scene where they are no longer needed. And the mechanism used most frequently is the general sclerosis or fibrosis of the whole body, particularly of the arterial system.

The change in the arteries in arteriosclerosis when seen under the microscope is in their innermost layers — the intima. A detailed account of this change need not detain us here. If anyone is stimulated by these notes to pursue the subject of pathology, let him turn to W. G. MacCallum's *Text-book of Pathology*, a mellow and delightful volume. Suffice it to say that the atheromatous or arteriosclerotic changes in the arteries, whether large or small, consist first in the deposit of a fatty material in the intima and a filling up of intimal cells around it. This leads later to a diminution in the calibre of the vessel and hence to a certain extent to a shutting off of the blood-supply to the part it nourishes. Later these plaques in the intima may ulcerate and have calcium deposits in them, and fibrous tissue may infiltrate into the entire artery.

When an artery going to a certain group of cells becomes obliterated or loses its resiliency, that group of cells either atrophies or degenerates or becomes functionally less active, depending on the degree of the obstruction of the artery. Thus if a small artery which goes to an islet of Langerhans in the pancreas becomes sclerotic, the islet-cells will degenerate; and exactly that change is found in the islets of Langerhans in the diabetes of middle-aged and elderly persons. If the artery going to a certain part of the brain becomes hardened and narrowed and furnishes less blood to it, the functions of that part of the brain will be entirely different from normal. And that is exactly what happens in the senile personality disorders and dementias. If the small arterioles which make up the glomerulus of the kidney undergo this change, a decided derangement of kidney function will result; and this is exactly what happens in the arteriosclerotic kidney of what is commonly called chronic Bright's disease. These and similar changes are of all lesions in the body the most final and least susceptible to repair.

Another cause of degeneration in important tissues is focal infection. The doctrine of focal infection and the elective localization of bacteria is one which has fascinated some of the most astute minds in the profession to-day. Some physicians who are competent judges believe that the atheromatous changes in the aorta and in the smaller arteries just described are due to focal infection. I do not share that view, but I am convinced of the frequent operation of focal infection and elective localization of bacteria in many conditions. Let me first state the basis of the doctrine.

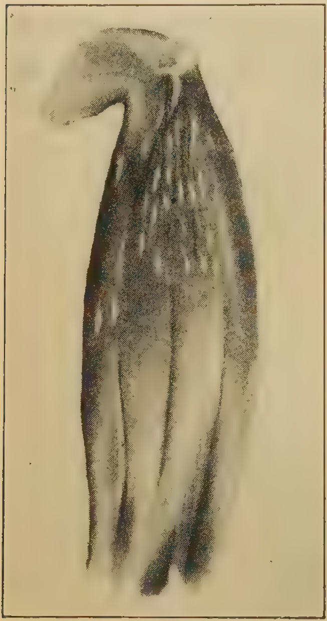

FIGURE 96

Muscle of rabbit. The rabbit has had injected into its abdomen a culture of bacteria from the root of a pulpless tooth of a patient who had muscular pains. The small white specks are areas of infection, from which the same bacteria cultured from the tooth were found. (Photograph loaned by Dr. R. L. Haden.)

Some years ago Dr. E. F. Rosenow, then associated with Dr. Billings in Chicago, found that in some cases of rheumatism or joint infection, the removal of teeth which had abscesses in their roots, or of infected tonsils, would result in the disappearance of the joint infection. Being a bacteriologist, he began making cultures from these infected teeth and tonsils. Most of the organisms he recovered were streptococci; under the microscope and in culture they all seemed very much alike. However, when Dr. Rosenow began to inject some of these cultures into guinea-pigs and rabbits, he found curious things. If he injected into a rabbit a culture containing the living germs grown from the tooth of a man who had rheumatism, the animal in a short time began to develop a limp and evident pain in the joints. When the animal was chloroformed and killed, a high-grade inflammation was discovered in the joints and in the muscles around the joints. In short, the rabbit which had received germs from the tooth of a man who had rheumatism, itself developed rheumatism. On the contrary, when a culture from the tooth of a patient with an eye infection, iritis, was injected into a rabbit, the rabbit developed a violent inflammation in the eyes. These were the only places in the body where the bacteria from the respective cultures seemed to light. The streptococci, for such they usually were, although they appeared alike in culture and in appearance, seemed to be different to the extent of having an affinity in the one case for the joints, in the other for the iris or eye structures. Their localization in the body was elective for these spots. Presuming that an infection had occurred in some focus such as the tonsils, the nose, or the teeth and that the bacteria from these foci sooner or later got out into the blood-stream, they would wander all over the body until they came to a structure the chemistry of which suited them, when they would settle down and begin growing.

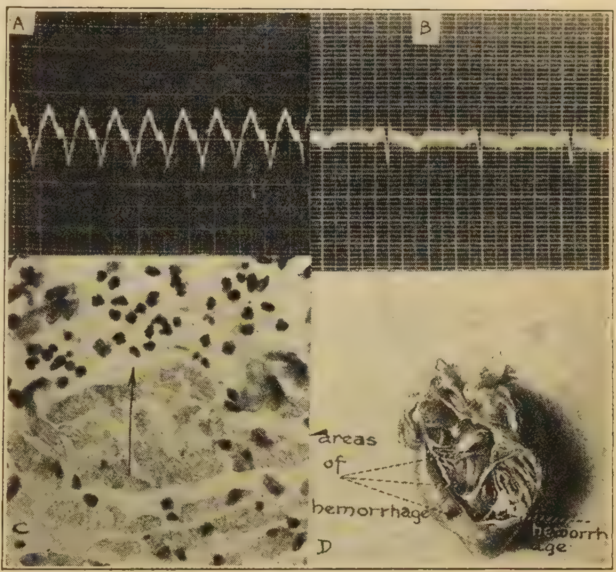

FIGURE 97

Heart of rabbit injected with bacteria from a focal infection in the tonsils of a patient with heart-disease. The pulse tracing A and B is an electrocardiogram of the patient.

Many other facts have been adduced since. The enormous frequency of such localized foci of infection is perhaps the fundamental one. The pertinacious activity of "American dentistry" resulted in leaving a generation universally endowed with abscesses at the roots of their teeth. We know now that it is almost impossible to put on a crown, to fill a root canal, or to clamp on a bridge without infecting the base of the teeth involved. The X-ray developed a technique of tooth examination which revealed these hidden infections. Dentists to-day are using an almost entirely revolutionized technique to try to avoid these dangers.

The tonsils, on account of the nature of their functions, particularly in infancy, become almost inevitably foci of infection. They stand in infancy at the entrance to the lungs and digestive tract and take up bacteria. Naturally in after life they are frequently found to have either abscesses or a chronic infection. The nose, the gall-bladder, the seminal vesicles, and other spots may harbour obscure infections.

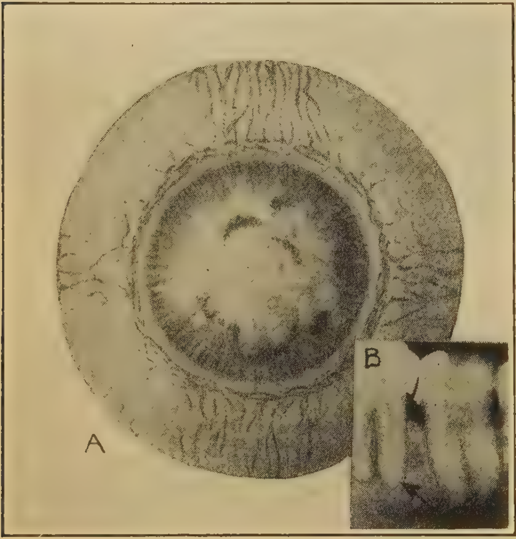

Figure 98

A. Eye of rabbit showing iritis. B. X-ray of tooth from patient with iritis.

Culture of bacteria from this tooth was injected into the rabbit, the eye of which is shown in A.

These infections are for the most part silent. The infected tooth or the infected tonsil causes no pain. That is the next important consideration to be understood. They go on sluggishly without causing pain or discomfort at the site of their growth. For this reason they were so long undiscovered.

A long list of diseases has been ascribed to focal infection as a cause. Arthritis, or joint infection, neuritis or neuralgia, muscular rheumatism, or myositis, may all certainly originate in this way. Dizziness, or vertigo, due either to a neuritis of the vestibular branch of the auditory nerve or to direct inflammation in the semicircular canals, is a common result of focal infection. More serious are the small abscesses in the heart-muscle and kidneys.

The question of whether atheromatous changes in the aorta and other arteries can be caused by focal infection has already been discussed. Gastric ulcer and endocarditis have been ascribed to this without, I think, complete proof.

Naturally an hypothesis of this kind, which is so attractive in content, and which is pragmatically capable of doing so much good, lends itself easily to exploitation. There has been in the last few years a perfect orgy of tooth-pulling and tonsil-removing. But after all, the amount of harm done has been small and the amount of benefit accomplished great.

As a means of summary, let me repeat that the proof of any lesion's being caused by a focus of infection lies in the reproduction of the lesion, to the exclusion of any other change, in the body of an experimental animal upon the injection of a culture of the suspicious infection.

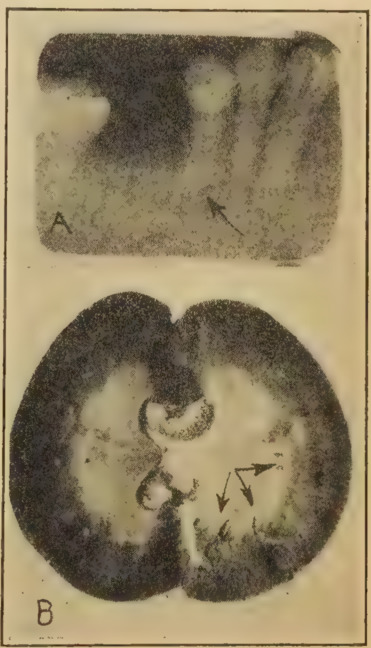

FIGURE 99

A. X-ray of infected tooth from a patient with kidney infection. B. Kidney of a rabbit into which a culture of the bacteria from the tooth shown in A was injected. Note areas of infection.

We have now studied two processes which may cause necrosis or necrobiosis, or degeneration of groups of cells in the body. One of these is the hardening and narrowing of the blood-vessels, thus shutting off nutriment to a given area. The other is the alighting of bacteria on a certain tissue, the bacteria having an especial chemical affinity and ability to destroy that tissue. Two other processes may operate in this way. One is interference with the blood itself in localized spots.

Thrombosis, embolism, infarction, and apoplexy are the names given to these changes. Thrombosis is the clotting of blood inside the blood-vessels; the clot so formed is called a thrombus. A thrombus may be formed at any place where the blood flows very slowly. For instance, when disease such as syphilis attacks the walls of a large vessel, and a dilatation, pouching, or aneurysm is formed, the blood begins to clot inside the pouch of the aneurysm. Where a vessel becomes narrowed from arteriosclerosis or has atheromatous plaques on its inner surface, small clots are liable to form at these places. Many "strokes of paralysis" are due not to the rupture of a vessel in the brain, but to thrombosis of a sclerotic cerebral artery. Severe forms of angina pectoris may be caused by thrombosis of the coronary arteries of the heart. Infection will promote a thrombosis, as in the clotting in the veins around a mastoid abscess or in the iliac veins following abdominal suppuration.

When a clot has formed in a blood-vessel, any part of the clot may wash off and be carried to another part of the body. These clots are called emboli, and the general process embolism. Any foreign body in the blood-stream is called an embolus. Thus we may have an air embolism, fat embolism, etc.

The embolus of whatever kind finally gets into a vessel too small to admit it and comes to rest. It plugs the vessel from there on. Whether or not the part affected is deprived of all blood depends upon anatomical circumstances. Most areas of the body are supplied with blood by two or three small blood-vessels. Some areas, particularly in certain organs, have single arterioles supplying them; they are called terminal arteries or arterioles. If an embolus strikes in a terminal artery, all the blood-supply to the part beyond is cut off and tissue necrosis ensues; this is called an anæmic infarct. If an embolus lights in an artery which is one of two or three which supply a part, a hæmorrhagic infarct results. Anæmic infarcts are common in the kidney, the spleen, and the brain; hæmorrhagic infarcts in the lungs and liver.

Apoplexy is the rupture of a vessel and hæmorrhage into the surrounding tissue. It is used in common parlance in reference to the brain, but may occur anywhere.

All of these occurrences will cause destruction to a greater or less extent of the cells of the area involved. Thrombosis and embolism cause necrosis simply by starvation — shutting off the blood-supply to a part. Apoplexy causes it by the pressure of the extravasated blood.

One final cause of tissue degeneration must be noticed. There used to be a disease much more common than it is now, when diagnostic methods are more astute. It was called amyloid degeneration, and consisted in the replacement of the normal tissue of important organs such as the liver, spleen, and kidneys with a gelatine-like substance named, from certain of its chemical reactions which resembled starch, amyloid. It occurred as a terminal result of chronic and wasting diseases, particularly the long-continued presence of pus in the body. This shows us that it is possible to have generated and absorbed into the body poisons which cause cell necrosis. It is not actual destruction by living bacteria, nor known chemical poisons immediately ingested, nor mechanical destruction, as by the pressure of blood from a ruptured artery, nor starvation from the shutting off of blood-supply by an embolus, but the internal elaboration of poisons which have an affinity for kidney-cells, liver-cells, heart-muscle-cells, etc.

Finally, it may be profitable to say a word about cell necrosis itself. Amyloid degeneration is not the only form, nor even the most frequent form, of it. Hyaline degeneration and granular degeneration both occur. Necrosis or necrobiosis is the name given to the death of a cell. "With the cessation of life in the cell, there is a short pause, during which the dead cell has every appearance of life, and then its protoplasm sets in a clot." The nucleus shrinks and then begins to fragment. The cytoplasm loses its structural outlines and degenerates into a granular mass. Finally the entire cell liquefies and disappears. If it is their nature, contiguous cells begin to multiply and take its place.

To summarize we have now studied several varieties of disease to which the body is liable: (1) wounds, cuts, or injuries; (2) the entrance of bacteria either in a localized spot or throughout the organism; (3) poisons; (4) heat, light, water, electricity, etc.; (5) hypersensitiveness to familiar substances — food, pollen, animal hair, etc.; (6) the degeneration which occurs as the result of the shutting off of the blood-supply to a set of cells, due to the process of hardening of the arteries and capillaries, or from thrombosis or embolism; (7) the deposit of toxins, or the lighting of bacteria from distant foci upon some internal organ. It is the last two which we have studied in this chapter. In all the forms of insult mentioned, the body has elaborated some form of defence; in some instances that defence is highly efficient; in others it consists simply in the necrosis or degeneration of a set of cells and their replacement by inactive fibrous tissue-cells. This applies especially to the two forms of injury last mentioned — those considered in this chapter.

The particular point is made that when a degenerative injury lights on any part of the body, the amount of damage it does depends not so much on the nature of the injury as on the vital importance of the organ involved.

If it lights on the skin, the damage is repaired with little or no permanent disability. So too the muscles. The lungs can fill in large areas of their substance by scar-tissue without interference with their functions. The liver has the power of regenerating its cells rapidly, and, unless the injury is very grave or frequently repeated, will be able to attain functional and anatomical integrity. But the kidneys, the brain, and the heart once injured have only limited powers of recuperation.

CHAPTER VI

NEOPLASMS, TUMOURS, CANCER, ETC.

The pathologic processes which we have so far considered have been, with one exception, the result of the interaction between an external force of deleterious nature which has entered the body and the protective measures which the body has learned to adopt towards such forces. The single exception is the development of arteriosclerosis or atheroma. This change in the vessels differs from all the others in that it is apparently the result of internal or automatic forces, that it is totally destructive in intent, and that the body is unable to raise up any successful defences against it.

We have now to consider another set of tissue changes, of a different nature, but which possess also these characteristics of autogenesis, of destructive intent, and of absence of the development of any bodily resistance. They are the new growths, the neoplasms or tumours, the best known of them being the group called cancer. It is impossible in the present state of our knowledge to be dogmatic about them. All the statements which I have just made are subject to certain qualifications. We know nothing about the cause of formation of one of them or of the forces which control or influence their development. We do know, however, a great deal about their gross and microscopical appearances, sufficient to be able to make a classification and practical diagnosis, and a great deal about the habits, the course, and the natural history of each type. I think it is perfectly fair to say that the present state of our knowledge allows us to issue the statements made above that neoplasms occur as a result of forces which are inherent in the cells, that they appear to be designed to terminate the individual's existence, and that the body forces seem to recognize all this as a part of nature's plan and to offer little or no resistance to its working out.

Nomenclature may concern us for a moment. We found that the suffix *-itis* designated inflammation. The suffix *-oma* designates

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a neoplastic change. Inasmuch as a neoplasm or a tumour may be a new growth in any kind of cell, the word designating the kind of cell concerned is placed first, and the suffix *-oma* appended to it. Thus a tumour of the bone is an osteoma; of epithelial tissue is an epithelioma; of fibrous tissue is a fibroma; of the neuroglia-tissue of the central nervous system is a glioma. The word "tumour" is used in medicine with at least two meanings. Essentially it means any kind of a swelling. Thus a pregnant uterus or an enlarged bladder may be called an abdominal tumour. Inasmuch as a new growth is a swelling, it is often called a tumour, although "neoplasm" is a more specific word.

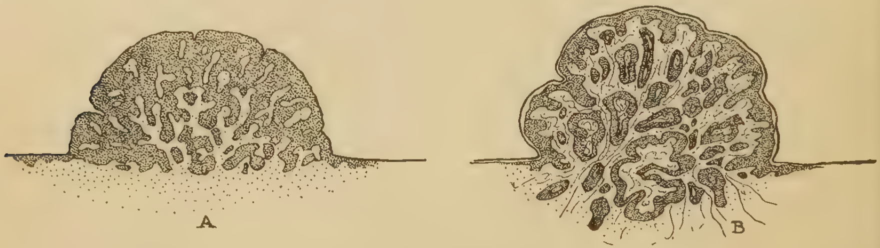

FIGURE 100

A benign epithelial tumour of the skin (A) compared with a malignant (cancer) epithelial tumour of the skin (B). Note that in both the tumour is composed of an overgrowth of cells normally present at that spot in the skin. But note that in the malignant tumour nests of cells have broken away from the basement layer and have set up independent growth colonies far below the level of the normal reach of skin-cells. These are diagrams of microscopic sections.

It is always easier to understand a subject if we proceed from the familiar and particular; I will therefore describe some examples of neoplasms which may be within the experience of everyone. The first one is — a wart. Plainly enough, if we analyse it, a wart is an overgrowth of the tissue in which it occurs — the skin. If a wart is cut out, sectioned, and put under the microscope, we see that it consists of an extension downward as well as upward, of cords of cells of the upper layer of the skin. Because these are the skin papillæ, the technical name of a wart is papilloma. The cells involved are exactly the same in appearance and chemical reaction as the normal cells of the skin. The condition seems to be a sudden multiplication of these cells. I cannot emphasize this point too much: a tumour is an enormous multiplication of the normal cells of the body. The growth or multiplication appears to be absolutely purposeless. It does not occur as the result of any kind of stimulation with which we are familiar. In the case of a wart, the growth reaches a certain, not dangerous, limit and stops. In order to remove the wart, all the cells involved must be destroyed.

As to cause, there are certain kinds of warts certainly due to infection — the warts in the beard region of old people especially. Others occur in the neighbourhood of inflammation — condylomata. But of others we know nothing of the cause. They may be cut out from one individual and implanted in a cut in the skin of another individual of the same species. If so, they shrivel up and die out. No wart remains on the skin of the second individual. They are therefore not infectious or contagious. Furthermore, some lack of growth balance, or chemical change must be present in the cells of the first possessor of the wart.

Thus by examination of so common and simple a condition we have described all of the fundamental principles of tumour growth.

Another common condition is a mass of fatty tissue which suddenly appears in a localized area under the skin. These are true neoplasms, and are called lipomas or, to Latinize the plural, lipomata. They are made up of fat-cells, differing in no observable particular from other fat-cells. Apparently they have formed as a result of one or more fat-cells in that region beginning to multiply until a collection of many thousands of fat-cells has piled up. Apparently also because the cells in the lipoma are to all appearance the same as other fat-cells, they have sprung from normal body fat-cells, previously existing at the site of the lipoma. They, like the papillomata, do not spread into other parts of the body, and are dangerous only when they grow to immense size, as they are capable of doing, or in such a locality as to embarrass a vital function, such as in the throat, embarrassing respiration. When removed surgically, they do not recur.

A third example may not be so generally familiar. In the uterus of a woman after the menopause it is common to find hard, round nodules, varying in size from that of a small marble to that of a child's head. They are composed of dense fibrous tissue exactly like the tissue of the uterine wall. Such a tumour is called a fibromyoma, because it is composed of fibrous connective-tissue-cells and smooth muscle-cells. Often these tumours also contain glandular tissue, when they are termed adenomyomata. In surgical slang they are called fibroids. They never set up growth outside the uterus. (This is subject to an apparent exception when such tumours are found growing in the abdominal wall or the umbilicus, but the exception is only apparent, as they then originate from misplaced uterine tissue.) Fibromyomas and adenomyomas may be dangerous through pressure on other organs and by eroding into blood-vessels and causing hæmorrhages. When removed surgically, they do not recur. Since they occur in the womb usually after the period of childbearing is over, they may be said to be degenerative processes in an atrophic organ. (They do not occur exclusively after the menopause, however.)

All the tumours so far examined have been of the class called benign. There is another class — the malignant tumours.

The two essential features of malignancy in a tumour are unlimited and recurrent growth and metastasis. Metastasis is the tendency to send cells into the blood- or lymph-vessels and set up new tumour growths at a distant part of the body. The two features of malignancy may be well illustrated in the skin cancer or epithelioma which grows at the margin of the lower lip. Such a site, where two types of epithelial tissue merge together, is a favourite one for cancerous change. When such a growth is examined under the microscope, the finger-like projections of papillomatous tissue, such as are seen in an ordinary wart, are observed; but something else, never observed in a wart, is seen. The growth is spread more widely beyond the skin line, and in spots the basement membrane of cells of the true skin is broken and nests of epithelial cells can be made out far below the farthest possible normal reach of skin-tissue. The cells are like ordinary skin-cells: the cancer is like the other tumours studied — made up of cells which have sprung and are growing from cells previously existing in that spot in the body. When such a tumour is observed in the living body, uninterfered with by surgery or other methods of treatment, it will continue its growth steadily and progressively. There is no natural stopping-point for it as there is for a wart. In the course of time the lymph nodes under the jaw begin to enlarge. They are hard and gritty, and, when seen under the microscope, nests of epithelial cells exactly like the cells of the skin cancer fill the lymph gland. This extension of the growth is the result of one or two cells of the cancer making their way into the lymph-stream, lodging in the lymph node, and starting to grow. In this way — called, as we have said, metastasis — the cancer can spread all through the body and start new development in distant organs. Soon lymph glands lower down in the neck and in the arm-pits are the site of these

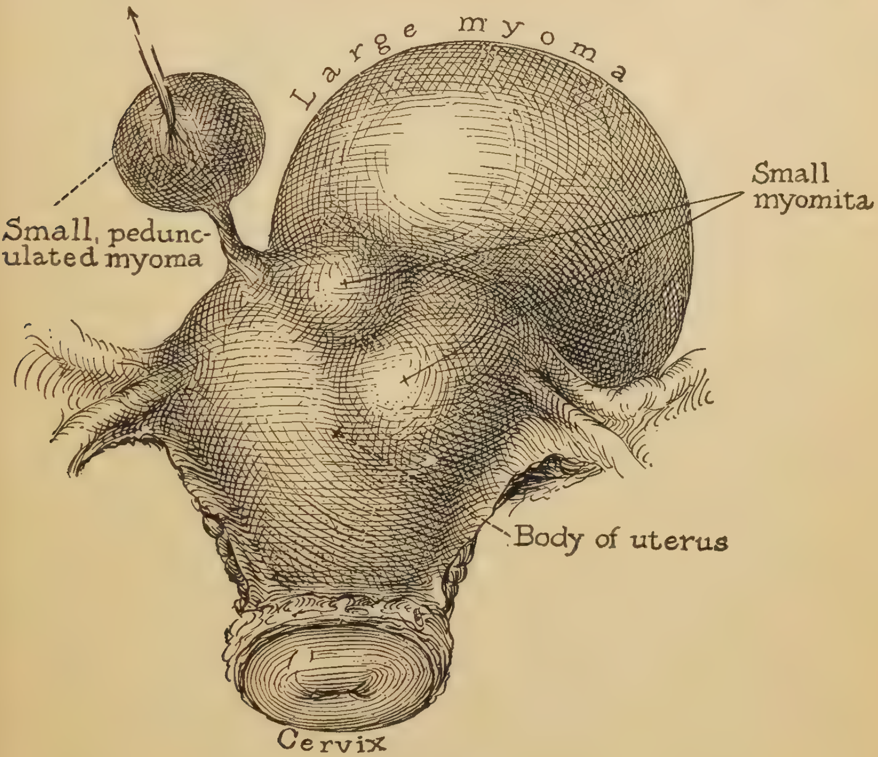

FIGURE 101

Fibroids (fibromyomas, or myomas, as is the proper designation) in the uterus. The artist, Mr. Shepard, has shown several forms of these tumours in a single uterus. Such an arrangement might occur, or any one could come singly. Small pedunculated (meaning on a stem) myoma seldom gives much trouble, unless the peduncle becomes twisted, when the blood supply is interfered with and degeneration may occur. The large subserous (which means under the covering of the uterus) myoma gives few symptoms until its size makes it known. The myoma in the body of the uterus close to the lining canal usually has a channel of the same sort of tissue as lines the uterus extending into it, and bleeding and discharge are usual symptoms from it. Thus the symptoms or danger from a "fibroid" depend upon many factors — size, position, and rate of growth. Before the days of anæsthetic and antiseptic surgery women simply had to suffer from these tumours. Now they can be removed with a minimum of risk and the patient's life prolonged.

new activities, and when the growth extends into the glands of the chest, the individual dies, either from pressure or hæmorrhage or general cachexia.

One other point needs to be made. We have said that the cells which make up the cancer are, in appearance, like the normal cells of the skin and it is a fair assumption that the cancer-cells are descendants of these normal skin-cells. They differ from them only in their character of unlimited and purposeless growth. That the cancer-cells resemble normal adult cells is true of the skin cancer. But in other cancers and other extremely malignant tumours, called sarcoma, the cells composing the tumour do not resemble any normal adult body-cells. They are undifferentiated. They are like the rounded cell depicted on page 49, which was drawn to represent a typical cell. Cells of this kind are found in the very young growing embryo. They have not become specialized; some of them will later be muscle-cells, with the particular character of contractility; some of them will be gland-cells, with the particular function of secretion; but in the embryo they are still undifferentiated and their most striking characteristic is an enormous impulse to multiplication and growth. When cells of this kind are found in a tumour, they too have this characteristic of wild impetus to multiplication. Therefore these tumours grow very fast and are the most malignant and least curable of all neoplasms.

These facts describe the fundamental phenomena of neoplastic disease. With them in mind it is possible to attempt a classification of all forms of tumours.

There are two main types of neoplasm, those of connective-tissue origin and those of epithelial-cell origin. Each has examples of benign and malignant tumours.

The benign connective-tissue neoplasms are:

(1) From fibrous tissue — Fibroma.
(2) From fat-tissue — Lipoma.
(3) From cartilage — Chondroma.
(4) From bone — Osteoma.
(5) From smooth muscle — Leiomyoma.
(6) From striped muscle — Rhabdomyoma (sometimes malignant).

(7) From nervous tissue — several kinds — Neuroblastoma, Glioma, Paraganglioma, etc. (usually malignant).
(8) From blood-vessels — Angioma.

Malignant connective-tissue tumours are called by the inclusive name "Sarcoma."

Benign epithelial tumours are:

(1) From skin epithelium — Papilloma.
(2) From gland tissue — Adenoma.

Malignant epithelial tumours are called Carcinoma. When the word "cancer" is used, at least in technical discussion, it is a carcinoma that is meant. (Some cancers of the skin are spoken of as epithelioma.)

There are several mixed cell tumours containing both connective tissue and epithelial tissue. They are of unusual interest because their occurrence formed the basis for one of the most completely reasonable of the hypotheses as to the origin of tumours. These are the teratomata, or tumours apparently of embryonal origin, such as the dermoid cysts which occur especially in the ovary and contain hair, fat, skin-tissue, teeth, and other heterogeneous elements.

Sarcoma may occur at any age, but is particularly likely to occur in young people, and even particularly likely to occur in infants. It may occur anywhere in the body where there is connective tissue. The most frequent sites are in bones, in fascia and tendons, in lymph glands, in the testicles and the kidney. The most striking characteristic of sarcoma is the rapid rate of growth and extreme destructiveness. It travels all through the body, almost entirely by way of the blood-vessels, in contradistinction to carcinomata, which metastasize by way of the lymph-vessels and nodes. The cells seen under the microscope in a sarcoma are unlike any normal adult cells seen in the body. They are apparently young and undifferentiated cells. Under the microscope they are seen to be full of mitotic figures, indicating rapid division. The mitotic figures are likely to be very atypical, not having the regular number of chromosomes, a habit to which normal body-cells are constant.

Carcinoma may also occur at any age, but is very unusual before the age of thirty, and most usual after the age of forty. It may occur anywhere in the body where there is epithelial tissue. The most frequent sites are the skin, particularly of the face, the breast (male or female), the uterus, the stomach, the rectum, the tongue, the intestines, the head of the pancreas, and the ovary. It metastasizes almost entirely in the lymph channels. Its rate of growth is not so rapid as that of the sarcomata, and it varies extremely in malignancy in various classes. Certain skin cancers are hardly malignant at all: they can be removed by the X-ray, radium, or surgery and never return. Cancer of the body of the uterus is far less malignant than cancer of the cervix of the uterus. About 40% of all cancers removed completely and early never return. An equal number are fatal no matter what is done. An epigrammatic surgical friend of mine says that if you will allow the Lord to choose his cancer, he will let the Devil choose his surgeon.

From all this we may summarize the essential characteristics of a neoplasm as a set of cells exhibiting a tendency to lawless and purposeless growth. We have repeatedly noticed in the body the very delicate tension of growth processes. A growing embryo grows just to the proper and necessary extent and then stops. A growing child grows just to the limit of what is normal for a human body and then stops. Even when a disturbance of one of the endocrine glands results in a dwarf or a giant, there are still definite statable limits within which that abnormal growth occurs. A healing wound shows a growth of new cells, to replace destroyed ones; when the necessary quota is reached, growth ceases. A neoplasm, on the contrary, grows without respect to any internal or external condition. Complete starvation of the rest of the body may occur, but the tumour grows on. An individual with a fatty tumour, a lipoma, may be emaciated until every vestige of fat elsewhere in the body is used up, but the fatty tumour will remain plump and intact. We are as ignorant of the causes of normal growth tension and balance as we are of the causes of wild and irregular tumour growth.

Furthermore all this growth is purposeless. Tumour-cells have no function. Tumours of gland structure do not develop any duct through which they could discharge their secretion, provided they had any. Sarcomata, connective-tissue tumours though they be, do not form any stroma or framework. No tumour is under the control of the nervous system, nor does any develop any nerve connexions.

When we come to inquire into the origin of neoplasms, all trace of dogma and data disappears. There are three main theories — the theory of parasitic or infectious origin, the theory of embryonal rests, and the theory of general biologic necessity.

It is only fair to note parenthetically that while no positive results have been obtained along any line, it is not for want of trying. Experimental cancer-research is being carried on all over the world by groups of the most honest-minded and indefatigable investigators the ranks of science can command. The problem has been attacked by every known method in the armamentarium of science. It has been attacked with the weapons of bacteriology, of immunity, of biologic chemistry, of physics, of physical chemistry, of tissue pathology, of genetics, of heredity, of animal experimentation, and of cytology. Those smug people who are wont to say: "Now it is time some of you medical men should get to work and find out the cause of cancer" are simply pathetically ignorant. We seem to have arrived at an impasse. We are in much the same position as the students of infectious diseases before Pasteur. When the key to the nature of neoplasms is found, if ever it is, it will probably be as new an idea as Pasteur's ideas of germs. And just as Pasteur's work opened up totally new fields, such as surgery and immunology, so this discovery will probably be felt in dark and obscure corners of human ignorance.

The infectious theory has always had, and still has, adherents. It is perfectly natural that, considering the wonderful results which came from the study of the infectious and contagious diseases along these lines, hope should be held out for a bacterial or parasitical origin of cancer. The difficulties in the way of the acceptance of such a theory are, however, almost insurmountable. If cancer is due to an infection, it is sufficiently different from any kind of infection that we know about to be in a totally different category.

There is no inherent reason why the tissue changes of neoplastic growths should not be due to a parasite. There are known to be tumefactions, microscopically resembling neoplasms in plants and animals, caused by definite organisms. The sugar beet is subject to a warty growth around its roots, caused by the *Bacillus tumefaciens*. As an instance in animals, Febiger found a parasite, the *Spiroptera neoplastica*, in the tissues of spontaneous stomach-cancer in rats; he found that it spent part of its life cycle in cockroaches and that the cockroaches deposited their ova on sugar in storehouses; by feeding 62 rats such sugar he developed stomach-cancer in 12 of them. No organism has, however, ever been even partially proved to be present in any human tumour.

What makes the infectious theory so difficult of acceptance is the total failure of any attempts at inoculation. There is nowhere in the record any proved case of the contagion of cancer from one person to another. And this, in spite of regular and continuous contact between cancerous and non-cancerous persons all over the world. Not only that, but the experimental results of the inoculation of cancer-emulsion-tissue are perfectly negative. All cancer-cells injected into another animal die out. Transplantation of cancer-tissue (not emulsified) acts like any other graft: that is, it can be performed successfully only from one to another individual of the same species. If you take out a portion of skin cancer from a mouse and graft it into the skin of a mouse of the same species, it will usually die out. With a large number of attempts, about 7% of the transplanted tumours will begin to grow. Transplanting these transplants yields a larger number of "takes," showing that a process of adaptation goes on. But even such results give little comfort to the holders of the parasitic theory, because the central part of the transplant always dies out, and only the cells at the edge in immediate contact with the living tissue of the host begin to live. If the significance of this is not perfectly plain, consider that if tuberculous tissue, for instance, were transplanted even to an animal of a different species, all the body-cells of the donor would die out, but in doing so would leave behind living tubercle bacilli which, if they grew at all, would set up tuberculous tissue changes *in the body-cells of the new host.* In transplanted tumours the body-cells of the host do not become cancerous at all.

The theory of embryonal rests is associated with the name of Cohnheim. He believed that tumours develop from masses of simple or complex tissue displaced during embryonal development. The young undifferentiated appearance and rapid-growth powers of certain tumours afford some support for this view. But it is a pure theory, as no embryonal rests can be found in tumour areas.

This leaves us with nothing very tenable except a loosely formulated conception which I venture to christen the theory of biologic necessity. It is a biologic necessity for nature to get individuals in a certain proportion daily and hourly out of the realm of the living. Cancer is one of the ways she has of doing it. The method seems to be hereditary transmission, the cancer-cells being fated to develop in the way they do from the period of the individual's birth. So far as I myself am concerned, the proof of the hereditary nature of tumours is final. This is, however, far from being the consensus of much better informed opinion than my own.

As support to the theory of the hereditary nature of tumours I refer again to Maude Slye's experiments with cancerous mice. They have been discussed before in this book. Briefly, this investigator found that cancer was very common in mice; by studying them carefully she was able to select out and breed together cancerous mice stock, not only generally cancerous individuals, but those both of which had cancer in the same organ. Thus she was able to produce in about five generations some strains which would show 100% of cancerous individuals. Her conclusions are that "the tendency to develop cancer and the capacity to resist cancer is unquestionably influenced by heredity," "that the resistance to cancer in mice acts as a Mendelian dominant character, and the susceptibility to cancer as a Mendelian recessive," that "not only the incidence of cancer, but its site and character are influenced by heredity," and even the localization of metastases seems to be influenced by heredity. These studies were carried on under the most painstaking conditions of control. Over 40,000 sections have been examined under the microscope in order to make certain that it was cancerous tissue that was involved.

The study of human heredity is very uncertain: very few people know the diseases their grandparents died of; almost none know the diseases all their grandparents died of. The problem is further complicated by the conscienceless and unscientific way humans have of marrying anyone they choose. If the sons and daughters of cancerous parents would marry the daughters and sons of other cancerous parents, we might get somewhere. Certain families have, however, been conspicuous for the incidence of cancer. Napoleon Bonaparte, his father, his brother Lucien, and two of his sisters, Pauline and Caroline, all died of cancer of the stomach. A less illustrious family is that reported by Broca, the family of Madame Z, which had sixteen people out of twenty-six die of cancer of the breast, liver, or uterus.

There are two recognized methods of treatment of neoplasms. One is surgery, the other is the use of radioactive forces — the X-ray and radium.

The aim of surgery in cancer is to remove every part of the proliferating cell area. With benign tumours it is very successful. If the benign tumour is in an area from which it can be completely removed, its nature is such that it will not return. The same holds true of a malignant tumour so long as it is localized. If the tumour has metastasized, has escaped from its local restrictions, surgery is ineffective. The surgery of the early twentieth century was very young and enthusiastic about the cure of cancer. It was just a question of removing enough tissue, enough chains of glands, a wide enough dissection. Experience has made surgery fatalistic at the early age of thirty-five. The most enthusiastic surgeons would hardly claim a higher percentage of cures of cancer than forty per cent, most of these in the skin of the face. Twenty per cent in cancer of the breast (testing your cures by waiting 15 years), fifteen per cent in cancer of the fundus of the uterus, five per cent in cancer of the cervix, no cures in cancer of the stomach. That is the record, the general experience of antiseptic surgery aided by competent pathology. No surgeon on earth would claim any better results than that; it would simply mean that the laboratory technicians of his hospital did not know cancer when they saw it.

I recall a striking incident of the days when the first grey fog of pessimism began to roll over the minds of surgeons. I was in consultation with one of the most brilliant surgical teachers who ever lived in this country. He had always a remarkable gift of simile. The case was that of a man with a cancer of the lip which had extended into one or two glands in the neck. The operation had just been completed. The patient's relatives were asking urgently if all the growth was out. My colleague refused to say. Finally, as they could not understand his reluctance, he took them to the window of the hospital, whence they could see the corner of a ploughed field. It was early spring. "Do you see that

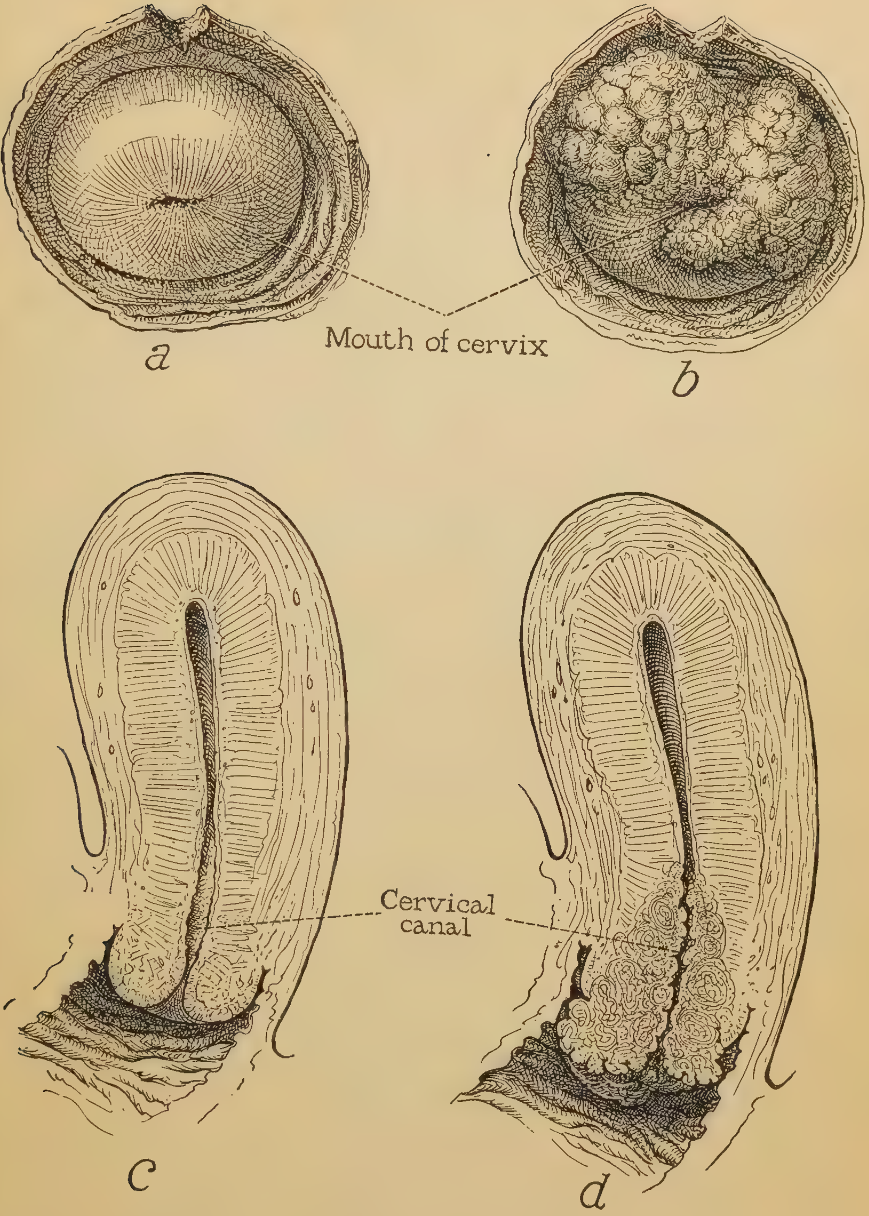

FIGURE 102

Cancer of the cervix of the womb. a. The normal cervix as it appears to the examining physician. b. The cervix which is cancerous as it appears to the examining physician. c. The normal womb cut lengthwise. d. The womb which has a cancer at the cervix, showing the extent of the growth. Operation to be successful in such cases must be done early enough, so that all the cancerous tissue can be removed. Irregular bleeding from the uterus s a danger signal.

field?" he asked. "I happen to know it is planted with wheat. I have perfect faith that in two months it will be covered with growing plants. Yet if we went over there now, I do not think I could find a single grain of wheat."

Both X-ray and radium exert the same action on cancer. It is not, as is commonly supposed, a specific destructive agent for cancer-cells. Radioactive agents do not, in other words, *kill* the cancer-cells. The action seems, on the contrary, to be that of bringing into play the latent resistive powers of the body to cancer. Certain modifications and reservations must be made to what we have already said about the absence of any protective reaction of the body to cancer. It is very rare, but spontaneous disappearance of malignant tumours has been recorded. For instance, Martin in 1908 reported a woman who had a cancer of the cervix of the uterus, the diagnosis being microscopically confirmed. She refused operation. Her family physician gave her condurango preparations. Twenty years later she was still alive, perfectly well. Wells, a most careful observer, has reported a case in which apparently metastatic nodules regressed after removal of the primary tumour. When such regression occurs, it seems to be accompanied by a marked round-cell infiltration around the edge of the growth. This same round-cell infiltration occurs around a cancer which has been subjected to the X-ray or radium. Therefore we believe that X-ray and radium act in cases of cancer which they cure by raising the resistive powers of the patient. Radioactive agents are most successful in superficial growths such as skin cancers, or following surgical removal

Chapter VII

DE SENECTUTE AND DEATH

In *Saint Joan* Shaw pictures at one place the Archbishop of Rheims saying sententiously: "We must all die some time" — at which his companion blurts out: "Oh! I hope not, sire." Aristophanes gives us the opposing view: the scene is in Hades; one of the shades threatens to return to life, horrible as that possibility is, unless his friend stops scolding. It is hard for man to reconcile himself either to life or to death.

Strictly speaking, death is not a biological necessity. There is no inherent reason why any cell should ever die. Years ago it was shown that vigorous tissue, such as young embryonal tissue with cells that had not adapted themselves to the reception of nutriment from blood-vessels and were absorbing it through their cell membranes, could be put into a flask with gelatine where the cells would live just as if attached to a living organism. The tissue died when the nutriment gave out. Then an ingenious modification of the experiment was made, so that the gelatine could be changed and renewed. Some cells of a chicken embryo placed in such a flask twelve years ago at the Rockefeller Institute are still alive, or were a year or so ago. There is no theoretical reason to suppose they will not live for ever.

For a complex organism like the human body there is, however, despite Le Hire's involuntary interjection, no hope. From nature's view-point it is much better so; she is for ever trying new experiments, new forms, working out her schemes with new individuals. However little we bore ourselves, in the course of time everything else is tired of us. Death itself is not unpleasant, I should imagine. I have seen a good many people die. To a few death comes as a friend, as a relief from pain, from intolerable loneliness or loss, or from disappointment. To even fewer it comes as a horror. To most it hardly comes at all, so gradual is its approach, so long have the senses been benumbed, so little do they realize what is taking place. As I think it over, death seems to me one of the few evidences in nature of the operation of a creative intelligence: of an intelligence exhibiting qualities which I recognize as mind stuff. To have blundered on to the form of energy called life showed a sort of malignant power. After having blundered on life, to have conceived of death was a real stroke of genius.

Before death stands old age. Montaigne said that to read Cicero's essay on old age made one long to grow old ("*Il donne l'appétit de vieillir*"). However bumptious it may appear to differ with a classic, I cannot agree with him. Even the inducement Cicero holds out that when one is old, one can sit in the senate, leaves me cold. No, there is nothing so horrible as old age. When the wrinkles begin to come, and vision blurs, and the breath comes short on attempting an incline! And even the cosmetician cannot cover the repetitious fund of anecdote.

So far as I am aware, medical science has no wisdom on these matters. You may be perfectly sure that if you live long enough, you will grow old, and that when you grow old, you will be unbeautiful and unattractive, and that surely death will come. When it comes, you may be certain you will disappear like all the rest and that you will not be missed, nearly as much as in your sanguine moments you have been inclined to suppose.

GLOSSARY

ABSCESS.	A circumscribed collection of pus.
ACIDOPHILUS BACILLUS.	A form of bacterium which grows only in an acid medium.
ACNE.	A pustular disease of the skin.
ADRENALS.	The ductless glands which are located above the kidneys.
ADRENALIN.	The secretion of the medulla of the adrenal gland.
ALLERGY.	The manifestations of idiosyncrasy to foods, animal emanation, and plants on the part of the body.
AMYLOLOPSIN.	The starch-splitting digestive enzyme of the pancreas.
AMYOTROPHIC LATERAL SCLEROSIS.	A disease of the spinal cord.
ANÆMIA.	Lack of blood. Whether lack of the number of red cells or lack of total amount depends on varying conditions.
APOPLEXY.	The common name for the rupture of a blood-vessel.
ARTERY.	A blood-vessel carrying blood from the heart.
ASTHENIC.	The long type of bodily structure.
ASTHMA.	A disease of the bronchi, manifested by difficulty of breathing.
ATROPINE.	A drug, the active principle of belladonna, which dries secretions, dilates the pupil of the eye, and increases the heart-rate.
AURICLE.	A chamber of the heart.
AUTONOMIC.	One part of the unconscious nervous system; the most important part of it is the vagus nerve.
BACILLUS.	A rod-shaped bacterium.
BACTERIUM.	A germ; plural, bacteria.
BASOPHILE.	Having a chemical affinity for alkali (especially alkaline dyes).
BENIGN.	Referring to a pathologic process, it means "not necessarily ending fatally."
BLOOD.	The bodily tissue which goes to all other tissues.
BRAIN.	A rare organ.
BUNDLE OF HIS.	The muscle-bundle in the heart along which contraction waves pass.
BURSA.	A sac-like (or closed) serous cavity.
CÆCUM.	The beginning portion of the large intestine.
CALORIE.	The unit of measure of heat, or heat energy.
CAPILLARY.	The smallest division of the blood-vessels.
CARBOHYDRATE.	Starch.
CARBOHYDRATES.	Starchy foods.
CATALYZER.	A substance which causes a chemical change without itself changing.
CELL.	The structural unit of living matter.
CEREBELLUM.	A part of the central nervous system. Located below the brain.
CEREBRUM.	A part of the central nervous system. Strictly, the brain.

Cervical Rib. An extra rib, growing from the vertebræ in the neck.

Cirrhosis. Hardening. Cirrhosis may occur in any organ. It is common in the liver. The cause is ascribed to alcohol indulgence.

Cochlea. The end organ of hearing.

Colon. The large intestine.

Colon Bacillus. A bacterium normal in the intestine.

Combustion. The process of burning.

Connective Tissue. Any collection of cells of the nature of connective cells.

Co-ordination. Smooth working.

Cord, Spinal. The lowest part of the central nervous system.

Chlorosis. A form of anæmia.

Chorda Tympani. A nerve which goes to the parotid salivary gland.

Chyle. Lymph loaded with fat, as it leaves the intestines.

Chyme. The pulpy mass of undigested food in the intestines. (Like time it waits for no man.)

Diastole. The relaxation period of the heart.

Digitalis. A drug, obtained from foxglove, which acts on the heart-muscle.

Dislocation. Change of position. Usually refers to a joint.

Embolus. A blood clot or other foreign body floating in the blood-stream.

Energy. The power by which anything acts effectively to move or change other things or accomplish any result.

Enzyme. A chemical body, usually secreted from a gland, which acts as a catalyzer.

Eosinophile. Having a chemical affinity for eosin, an acid dye.

Epilepsy. A nervous disease characterized by convulsions.

Epiphysis. See *Pineal.*

Epithelium. A tissue made up of epithelial cells; they are usually on surface areas, such as the skin, the lining of the mouth, windpipe, stomach, intestines, and bladder.

Erysipelas. An infectious disease the chief manifestation of which is on the skin.

Evolution. A proved law of biology. It explains the mutation of living organisms.

Expiration. The period during which air is expelled from the lungs.

Fibre, Nerve-. The extension from a nerve-cell. It makes connexions with other nerve-cells, with muscles, or with sensory end organs.

Fibrinogen. The substance in the blood which forms fibrin, which is the firm part of a blood clot.

Fracture. Solution of continuity.

Functional. In use by physicians to designate an ailment which has no anatomic basis. The opposite of organic.

Glucose. A simple form of sugar.

Glycogen. A starch produced in animal livers. It is formed from glucose. When energy is needed by the muscles, glycogen is converted into glucose and sent to the muscles and burned.

Hæmophilia. A disease of the blood characterized by lack of rapid coagulating power.

HEPATIC FLEXURE. A portion of the large intestines under the liver.

HERPES ZOSTER. An eruption of blebs (serum-filled eruptions) on the skin. Due to a disturbance (usually hæmorrhage) into a nerve-ganglion.

HORMONE. A chemical substance, usually elaborated by a gland of internal secretion, which after absorption into the blood co-ordinates certain vegetative bodily functions. Examples are epinephrin, the secretion of the adrenal glands, insulin, the internal secretion of the pancreas, and thyroxin, from the thyroid.

HYPERTENSION. The state of high blood-pressure.

HYPERTROPHY. A tissue change of enlargement.

HYPOPHYSIS. See *Pituitary.*

INDOL. A chemical constituent of the fæces.

INFLAMMATION. The succession of changes in living tissue, due to injury.

INSPIRATION. The period during which air enters the lungs.

KELOID. A tumour of connective tissue.

KYPHOSIS. A deformity of the spine.

LACTOSE. A simple form of sugar found in milk.

LANGERHANS, ISLETS OF. The ductless glands embedded in the pancreas.

LAPAROTOMY. The act of cutting open the abdomen.

LEUCOCYTE. One of the white cells of the blood.

LEUCOCYTOSIS. An increase in the white cells of the blood. Usually used in reference to infection.

LEUKÆMIA. A disease of the white cells of the blood.

LYMPH. A colourless alkaline nutritive fluid in animal bodies, probably derived from blood-serum.

LYMPHOCYTES. A group of the white cells of the blood.

MALIGNANT. Referring to a pathologic process, it means of a grave nature, tending towards a fatal outcome.

MASTOIDITIS. Inflammation of the mastoid cells of the ear.

MEDULLA OBLONGATA. A part of the central nervous system. It contains large ganglia, such as the origins of the cranial nerves, and it also contains many fibres from the cord going to the brain and vice versa.

METABOLISM. Nutrition.

METAPLASIA. Change of one tissue into another.

MITOTIC. Referring to the usual form of cell division. The opposite of direct division.

NECROSIS. The destruction of cells.

NEOPLASM. A tissue change in the nature of an overgrowth of cells.

NEPHRITIS. Inflammation or change from normal in the kidney.

NEURON. A single nerve-cell.

NITROGENOUS. Containing nitrogen.

OMENTUM. A portion of the peritoneum. It is an apron of fat and blood-vessels.

ORGANIC. In use by physicians to designate an ailment which has an anatomical change as a basis. The opposite of functional.

OVARIOTOMY. The act (surgical) of opening the ovary.

OVARY. The female germ organ.

PANCREATITIS. Inflammation of the pancreas

Penis. A portion of the male genital tract.

Pepsin. The digestive enzyme of the stomach (digests only proteins).

Peristalsis. The involuntary action of the gastro-intestinal muscles.

Pernicious Anæmia. A disease of the blood and blood-forming system.

Phagocytosis. The accumulation of the white cells of the blood, usually in response to bacterial invasion.

Phenolphthalein. A chemical used as an indicator of acid and alkali, which has also cathartic properties.

Phrenic. Referring to the diaphragm.

Pilocarpin. A drug which causes sweating.

Pineal. A ductless gland, located in the skull cavity.

Pituitary. A ductless gland, located at the base of the brain.

Prostate. A large gland at the base of the male bladder.

Ptyalin. The digestive enzyme of the salivary glands.

Purpura. A disease of the blood, in which the bleeding time is prolonged.

Pylorus. The outlet of the stomach into the intestines.

Sclerosis. Hardening, or ingrowth of connective tissue.

Scoliosis. Twisting, usually referring to the spine.

Selection. The method employed to change species by intensive breeding. It may be natural or deliberate.

Serous. Referring either to a watery fluid secreted by the serous membranes or to a type of cell lining the membranes of the great body cavities, particularly the peritoneum, the pleura, and the pericardium.

Serum. The part of the blood which is squeezed out of the clot. The liquid part of the blood.

Shingles. (Medical use) Herpes Zoster (q.v.).

Shock. A bodily state, characterized by rapid pulse, pallor, mental collapse, and great prostration.

Skatal. An evil-smelling chemical constituent of the fæces.

Somatic. Bodily or visceral: see *Vegetative.*

Spinal Cord. See *Cord, Spinal.*

Spleen. An organ belonging to the blood system.

Splenic Flexure. A portion of the large intestine under the spleen (left of abdomen).

Steapsin. The fat-splitting digestive enzyme of the pancreas.

Systole. The contraction period of the heart.

Testes. The male germ organ.

Thalami, Optic. Large ganglia at the base of the brain.

Thrombus. A blood clot formed in a blood-vessel.

Thymus. A ductless gland, located in the chest. It atrophies at about the age of fourteen.

Thyroid. A ductless gland in the neck.

Tissue. Any collection of living cells in one organism.

Toxic. Poisonous.

Trypsin. The protein-splitting digestive enzyme of the pancreas.

Tubes, Eustachian. The connexion between the throat and the middle ear.

TUBE, FALLOPIAN. The portion of the female organs of reproduction which serve to conduct the ova from the ovary to the uterus.

TUMOUR. A swelling.

ULCER. A solution of continuity in a mucous membrane.

UTERUS. The womb.

VAGINA. A portion of the female genital tract.

VEGETATIVE. Referring to the bodily, as distinguished from the voluntary or psychic, functions of the body; somatic.

VEIN. A blood-vessel, carrying blood towards the heart.

VENTRICLE. A chamber of the heart.

VISCERA. Organs of the body, as the heart, lungs, stomach, liver, intestines, brain, kidneys, etc.

VITAMINS. Chemical constituents of foodstuffs which have great influence on nutrition.

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